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ANNUAL HISTORICAL REPORT
CALENDAR YEAR 1989

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

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ANNUAL HISTORICAL REPORT -- AMEDD ACTIVITIES

RCS MED-41 (R4)

U.S. ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

NATICK, MASSACHUSETTS 01760

CALENDAR YEAR 1989

USARIEM
CY89

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GENERAL INFORMATION

ORGANIZATION

The United States Army Research Institute of Environmental Medicine (USARIEM) is organized with an Office of the Commander/ Scientific Technical Director, seven Research Divisions and a Research Support Division consisting of five functional Branches. Organization chart of USARIEM, dated 1 October 1989 is attached as Appendix A.

LOCATION

USARIEM is located at the United States Army Natick Research, Development and Engineering Center (Natick), Natick, Massachusetts 01760

ACTIVATION AND ASSIGNMENT

a. By Section VI, General Order 33, Headquarters, Department of the Army, 20 September 1961, USARIEM was established as Class II activity under the jurisdiction of The Surgeon General, effective 1 July 1961.

b. General Order No. 40, Department of the Army, Office of the Surgeon General, 1 December 1961, assigned USARIEM to the United States Army Medical Research and Development Command, Washington, D.C., effective 1 July 1961.

c. The USARIEM was last reorganized under General Order No. 32, Department of the Army, Headquarters, U.S. Army Medical Research and Development Command on 1 August 1975.

TENANCY

a. USARIEM is a tenant on the Natick installation and receives administrative and logistical support from the Natick on a reimbursable basis and in accordance with an annually renewed intra-Service support agreement.

b. The Pikes Peak Laboratory Facility, Colorado, is a subordinate activity of the USARIEM and is utilized on a seasonal basis when a research requirement exists.

MISSION

Conducts research on the effects of temperature, altitude, work and nutrition on the health and performance of the individual soldier and combat crews operating Army systems. Assesses decrements to soldier or combat crew performance caused by the synergy of environmental extremes protective measures used in NBC sustained operations. Conducts research on the biomedical processes limiting physical performance to determine physical fitness requirements and seek solutions to medical problems related to physical training and exercise. Defines the complex interaction of environmental/operational stress and Army systems and develops, evaluates and assists in the implementation of strategies designed to protect the soldier and enhance performance. In coordination with the Natick Research, Development & Engineering Center (Natick) and through liaison with other Federal agencies, conducts research to develop the technology base required to evaluate feeding strategies for operation rations and supplements to minimize soldier performance decrements under sustained combat conditions and discharge the Army Surgeon General's responsibilities as DOD executive agent for nutrition. Assists Natick in the development of personal clothing and equipment by assessing the physiological impact of these items under all climatic conditions. Provides technical advice and consultant services to Army commanders, installations and activities in support of the Army Preventive Medicine Program and, on request, to other Federal agencies.

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PERSONNEL

STRENGTH AS OF: 31 December 1989

CIVILIANS	AUTHORIZED	ACTUAL
SES	1	1
GM	7	7
GS	88	76
WG	2	1
TPT	2	12

OFFICERS	AUTHORIZED	ACTUAL
MC	5	6
MS	12	12
VC	3	3
SP	2	2

ENLISTED	AUTHORIZED	ACTUAL
	54	51

TOTAL:	AUTHORIZED	ACTUAL
	176	171

KEY STAFF AS OF: 31 DECEMBER 1989

Joseph C. Denniston, COL, VC, Ph.D., Commander and Scientific/ Technical Director

John F. Glenn, LTC, MS, Ph.D., Deputy Commander

Lawrence K. Lightner, MAJ, MS, Ph.D., Executive Officer and Director, Research Support Division

Celso Santiagomorales, SSG, Chief Medical NCO

James A. Vogel, Ph.D., Director, Exercise Physiology Division

Kent B. Pandolf, Ph.D., Director, Military Ergonomics Division

Richard R. Gonzalez, Ph.D., Chief, Biophysics Branch, Military Ergonomics Division

Michael N. Sawka, Ph.D., Chief, Physiology Branch, Military Ergonomics Division

Roger W. Hubbard, Ph.D., Director, Heat Research Division

Allen Cymerman, Ph.D., Director, Altitude Research Division

Murray P. Hamlet, D.V.M., Director, Cold Research Division and Acting Chief, Cold Injury Branch

Wilbert D. Bowers, Ph.D., Chief, Experimental Pathology Branch, Cold Research Division

Andre A. Darrigrand, MAJ, VC, D.V.M., Chief, Animal Care Branch, Cold Research Division

Eldon W. Askew, LTC, MS, D.V.M., Director, Military Nutrition Division

Terry M. Rauch, MAJ, MS, Ph.D., Director, Health and Performance Division

KEY STAFF (continued)

RESEARCH SUPPORT DIVISION:

Jacqueline F. Amaya, 1LT, MS, Adjutant/Detachment Commander
Dwayne A. Cruz, CPT, MS, Chief, Logistics Branch
John M. Foster, Chief, Bioengineering Branch
Marie E. Stephens, Personnel/Manpower Resource Management Branch
Violet M. Trainer, Program and Budget, Resource Management Branch
Vacant - Chief, Information Management Branch

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ALLOCATION AND FUNDING

DA PROJECT NO. AND TITLE	FUNDS
3M161102BS15 - Science Base of System Health Hazard Research	$1,450,000
3E162787A3GL - Administration and Management	1,661,000
3E162787A875 - Medical Defense Against Chemical Agents	185,000
3E162787A878 - Health Hazards of Military Materiel	340,000
3E162787A879 - Medical Factors Enhancing Soldier Effectiveness	1,449,000*
3M263002D819 - Field Medical Protective Device	438,000
3M263002D995 - Medical Countermeasures to CW Agents	313,000
3M463751D993 - Medical Defense Against Chemical Countermeasures	395,000
3M463807D836 - Combat Medical Materiel	45,000
Total FY89 Program	$6,276,000

* An additional $613,000 was received 28 December 1989 for: (1) critical facility requirements needed to sustain essential research operations; (2) upgrading in-house medical care facilities to assure the safety of test subjects; and (3) updating and replacement of outmoded research equipment. The revised total for Project No. 3E162787A879 is $2,062,000.

SUPPLY AND MAINTENANCE ACTIVITIES

During CY89, a total of 1,600 requests were processed by the Logistics Branch as indicated below:

Non-Expendable	- 157 requests
Expendable	- 1,449 requests

Additionally, the Logistics Branch turned in 448 items of excess equipment, processed four reports of survey, and submitted 46 work orders and 398 maintenance service orders to Facilities Engineering.

The Medical Maintenance Section performed preventive maintenance on 2115 items, and sent 427 items to calibrations.

BUILDING AND FACILITY EQUIPMENT

INSTRUMENTATION DESIGN AND DEVELOPMENT

The Bioengineering Branch contributed to the design and development of the following for the period CY89:

a. Textile Water Vapor Resistance Measuring Apparatus. (Initiated)

b. Plexiglass Rat Maze. (Completed)

c. Treadmill validation of combat boot insert prototype, Activity sensor and data acquisition device for combat boot insertion. (Phase II prototype completed and treadmill tested)

d. Peripheral Vision Stimulus Array. (Mechanical Structure Completed)

e. Electronic Controller for Peripheral Vision Stimulus Array. (Initiated)

f. High Air Pressure/Water Alarm for Hypobaric Chamber. (Initiated)

g. Precise Pedal Position Measurement System for Superbike Ergometer. (Completed)

h. Environmentally Protected Tachometer for Armcrank Ergometer. (Completed)

i. Digital Elapsed Timer for Immersion Pool area. (Completed)

j. Moving Laser Target Tracking Device for performance testing using the M-16 rifle. (Initiated)

k. Automatic Target Detection and Reaction Timing Device for Weaponeer performance testing protocols. (Initiated)

l. Instrumenting a standard Army canteen to measure water consumption during field operations. (Initiated)

m. Army Heat Stress Monitor based on WBGT measurement technology. (Formulated the specification and presented a design proposal for fabrication)

n. Pneumatic Control and Drive System Upgrade for the Repetitive Lifting Device. (Initiated)

o. High Voltage/High Current Lighting Control System with computer interface for Biomechanical Analysis of Load Carriage studies. (Completed)

p. Test Subject Pacing Device to cue test subjects for required approach speeds when using Force Platform apparatus. (Completed)

q. Adjustable Ergometric Chair for underwater use on "fin bike" ergometer. (Initiated)

BUILDING MODIFICATIONS

a. Contract awarded for asbestos removal from Mechanical Equipment Room 025. Removal scheduled for May 1990.

b. Architectural engineering design contract awarded to remove asbestos from the rest of the building.

c. Architectural engineering design contract awarded to totally upgrade heating, ventilation, air conditioning, and plumbing systems.

d. Redesign of Small Conference Room initiated.

e. Installation of 750 KVA 440 volt transformer and associated switch gear.

f. New biowaste incinerator and stack installation. (Completed)

g. Furnished 900 sq. ft. of office space for the Military Nutrition Division. This Health Clinic Annex space was made available from Natick through terms of the Host Tenant Agreement.

h. Scope of work to upgrade Environmental Chamber 236 Complex. (Completed)

ALTITUDE RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. A number of physiological responses and adjustments occur at high altitude to compensate for the hypoxia. It was hypothesized that interference with one component of the normal compensatory process, the sympathetic nervous system, would hinder altitude acclimatization and thereby exacerbate acute mountain sickness and compromise well-being of soldiers exposed to high terrestrial elevations. Twelve males received either 80 mg propranolol (n=6) or placebo (n=6), t.i.d. at sea level and during the first 15 days of a 19-day residence at 4300 m. Throughout the entire altitude exposure, the group taking propranolol reported lower or equal symptom severity compared to the placebo group as determined both by responses on the Environmental Symptoms Questionnaire and medical interview. These findings suggested that interference with the normal acclimatization process by beta-adrenergic blockade did not exacerbate acute mountain sickness. The tachycardia that occurs in response to the hypoxia of high altitude has been shown previously to be an important response in maintaining cardiac output during a central circulatory challenge at altitude. However, it was not known if the tachycardia was an essential response given that stroke volume is also reduced at high altitude. Twelve males received with 80 mg propranolol (n=6) or placebo (n=6), t.i.d. at sea level and during the first 15 days of a 19-day residence at 4300 m. Upright tilt tests were performed at sea level and at high altitude during days 2, 7, and 15 while on drug treatment and on day 19 of the altitude exposure without placebo or propranolol treatment. While on treatment at sea level and altitude, propranolol caused significant reductions in heart rate and blood pressure in the supine and upright positions. Supine and upright cardiac outputs, however, were found not altered due to compensatory increases in stroke volume. It is concluded that the altitude-induced tachycardia, both at rest and during upright tilt, is important but not essential to maintain cardiac output during exposure to high altitude. (Publications: 8, 9; Briefings: 31, 33, 34, 35, 37, 38)

ALTITUDE RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

2. Four mg dexamethasone (q.i.d.) has been previously found to be highly effective in preventing acute mountain sickness symptoms in young men exposed to 4570 m altitude. However, the effective dose may be lower and could be administered less frequently, making the drug more appropriate for widespread field use. The present study was conducted to determine whether lower, safer doses administered less frequently (b.i.d.) would be as effective. Twenty-eight young males were exposed to a simulated altitude of 4570 m for 45 hours in a hypobaric chamber while taking one of three doses of dexamethasone (4 mg, 1 mg, or 0.025 mg every 12 hours) or placebo in a double-blind, crossover design. Only the 4 mg dose reduced the incidence of acute mountain symptoms. There was no evidence of adrenal cortical suppression 48 hours after treatment with dexamethasone. These results indicate that 4 mg of dexamethasone twice daily by soldiers who will be exposed to high terrestrial elevations is an effective prophylactic treatment for acute mountain sickness; lower doses are not efficacious. (Publications: 24; Briefings: 31, 33, 38)

3. Aerotitis media (barotrauma, ear block) was studied in human subjects during simulated high altitude ascent and descent using a modified commercially-available tympanometer. Twenty-two males and nine females, 22-43 years of age were tested in each ear with the tympanometer prior to and after exposure, sequentially at the barometric pressure plateaus of 706, 656, 609, 586, 564, and 522 mm Hg, and following an induced ear block during a 1-min descent from 522 to 586 mm Hg. Each subject was examined once either alone or in pairs during a 90-min exposure. Aerotitis media was detected using tympanometry at simulated altitude as evidenced by the difference between measurements made during induced ear blocks and those made prior to inducement, as well as following relief of the pressure differential with the Valsalva maneuver. There were no significant differences between pre- and post-hypobaria. Tympanometry is an available tool for detecting middle ear

ALTITUDE RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

barotrauma during simulated high altitude ascents and descents and is recommended as a diagnostic tool in all military hypo- and hyperbaric chamber operations.

4. The use of nylon shell, insulated double boots by high-altitude climbers has resulted in documented reports of cold injury to the feet, especially the toes. In many cases involving injured climbers, the use of a closed-cell inner boot foam lining was noted. Physical changes to the inner boot linings of the same design were investigated during hypobarism. A new foam inner boot was placed in a sealed chamber filled with a known volume of water and placed inside the hypobaric chamber. Volumetric changes to the inner boot were measured by displacement of water from the chamber as a function of decreasing ambient pressure. Total insulation value (I_t, m^2KW^1) of the completed boot was also measured using a heated foot model which calculated thermal resistance. At sea level, the inner boot displaced 1404 ml of water, while at 5490 m the volume displaced was 1788 ml resulting in a 27% increase in inner boot volume. I_t values of the boot and a thick wool sock increased from 0.32 at sea level to 0.36 at 9150 m. The increased displacement of water by the inner boot at altitude was attributed to the expansion of gases trapped in the closed cells of the foam material. This expansion resulted in a corresponding increase in I_t. The omni-directional expansion of the inner closed-cell foam boot lining could likely lead to restriction of peripheral blood flow in toes increasing the potential for cold-induced injuries in soldiers at altitude.

5. An *in vitro* system has been developed for use in the study of the response of isolated perfused lungs to hypoxia. The purpose of these studies is twofold. The primary goal is to explore the mechanisms by which environmental hypoxia produces increased pulmonary vascular resistance and pulmonary hypertension. The ultimate goal would be to identify specific agents that could be used in soldiers to prevent or treat high altitude pulmonary edema.

ALTITUDE RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

A secondary goal is to explore pharmacological interventions which might modify this response to hypoxia. Preliminary studies are underway to identify variables in experimental procedure which might significantly affect pulmonary vascular responses. These variables include magnesium concentration, phosphate concentration, and the presence of phenol red in the perfusate.

6. During a deployment of U.S. military personnel from Panama (sea level) to Bolivia (12,000 - 13,000 feet) during Exercise Fuerzas Unidas Bolivia 89, only 31.5% of Army personnel took recommended acetazolamide (Diamox). Noncompliance to the recommendation was attributed to the flat taste of carbonated beverages and paresthesia. Two cases of high altitude pulmonary edema and one case of hypoxia-induced sickle cell crisis with splenic infarction were identified and treated among 108 personnel flown into Bolivia during the first week of the exercise. A U.S. Air Force crewmember experienced symptoms of decompression sickness during the depressurization of a C-141B aircraft during descent into Lapaz, Bolivia (13,300 feet). Hyperbaric treatment resolved the symptoms. (Briefings: 31, 33, 34, 36, 38)

7. Exposure to high altitude results in a decrease in blood glucose utilization during prolonged exercise. Six normal adult male soldiers (27 ± 2 yr, SEM) were studied at sea level and after 13-14 days at high altitude (3700-4300 m). The rate of lipolysis, i.e., glycerol release into the blood (Ra glycerol), and glucose appearance (Ra glucose), were measured during 4 h of uninterrupted treadmill exercise at 51% ± 1.01 SEM of the environment-specific VO_2max. Ra glycerol and Ra glucose were quantified by a primed, constant infusion of $[D_5]$ glycerol and $[6,6\ D_2]$ glucose, respectively. Both Ra glycerol and Ra glucose increased significantly during the 4 h of exercise, while total glycerol release was unchanged (283.5 ± 14.5 mM at sea level vs. 237.2 ± 30.8 mM at high altitude). These data indicate a decrease in the fractional contribution of blood glucose to fuel metabolized during

ALTITUDE RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

prolonged exercise at high altitude and provide a basis for establishing the nutritional requirements of soldiers in this environment. (Publications: 4, 14; Abstracts: 16, 20, 21; Presentations: 29, 30)

8. Cachectin, or Tumor Necrosis Factor, has been suggested as a possible factor responsible for the anorexia observed in humans exposed to high terrestrial elevations. Plasma cachectin levels were measured in ten healthy male soldiers at rest at sea level, and following 10 days at 4300 m elevation. Although there was a significant decrease in food intake, there was no significant change in plasma cachectin levels. These data suggest cachetin does not play a role in the loss of appetite of soldiers after 10 days at 4300 m elevation. Anorexia continues to be a problem in military operations at altitude. (Abstracts: 16)

9. A six-day field test was conducted to measure the energy expenditures, activity patterns and nutrient intakes of 10 Special Operation Forces soldiers. These soldiers consumed a liquid carbohydrate supplement and the Ration, Lightweight during a strenuous cold weather high altitude training exercise on Mt. Rainier, WA (2100-3300 m). Energy expenditure calculated by the intake/balance method was 4294 ± 384 kcal/day (12% protein, 34% fat, 54% carbohydrate). Approximately one-third of the carbohydrate intake was from the beverage supplement (103 ± 44 g/day or 412 kcal/day). This additional carbohydrate probably reduced potential decrements in physical performance by helping to restore and maintain body glycogen stores. This study demonstrated the potential value of a liquid carbohydrate supplement during military exercises at high altitude. (Publications: 4, 13, 14; Abstracts: 20, 21, 25; Presentations: 29, 30)

10. The effects of endurance exercise, acute altitude exposure, and chronic altitude exposure (14 days at 3700-4300 m), on soldier marksmanship performance was quantified. Sixteen Special Forces

ALTITUDE RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

soldiers dry fired an M16 rifle equipped with a Noptel ST1000 laser system from a standing unsupported position at a 2.3 cm diameter target from a distance of 5 m. Subjects were tested at rest and after a strenuous 20.4 km run/walk ascent from 1830 m to 4300 m, following acute altitude exposure and after chronic altitude exposure. Sighting time (the interval between signal light presentation and firing) and accuracy (distance of shot impact from target center) were measured. Exercise and time at altitude had independent effects on marksmanship. Sighting time was unaffected by exercise, but was 8% longer following chronic altitude exposure (5.61 ± 1.25 sec on acute exposure vs 6.06 ± 1.06 sec after chronic exposure, mean ± SD). Accuracy was reduced by 10.5% with exercise (3.63 ± 0.69 cm from target center at rest, to 4.01 ± 0.89 cm post-exercise, but improved 15.5% with chronic altitude exposure (4.14 ± 1.02 cm on acute altitude exposure, to 3.50 ± 0.92 after 14 days at 4300 m elevation).

11. High-altitude exposure may accelerate the rate at which drugs are metabolized. Eight healthy male soldiers (23-35 years of age) were studied at sea level and after 16 days at 4300 m elevation. Hepatic blood flow was indirectly quantified using indocyanine green dye elimination. Caffeine was administered orally, and its rate of removal from blood monitored via serial blood sampling. Hepatic blood flow was indirectly quantified using the rate of dye elimination. Hepatic blood flow increased 118%, and caffeine clearance increased 30%, suggesting that altitude exposure decreases the availability of caffeine. This study suggests that altitude exposure may have similar effect on the hepatic metabolism of other drugs such as anti-inflammatories and analgesics which are readily available to soldiers in an altitude environment. (Publications: 10; Abstracts: 22; Presentations: 27, 28)

ALTITUDE RESEARCH DIVISION

PUBLICATIONS:

1. Bender, P.R., B.M. Groves, R.E. McCullough, R.G. McCullough, L.A. Trad, A.J. Young, A. Cymerman and J.T. Reeves. Decreased exercise muscle lactate release after high altitude acclimatization. J. Appl. Physiol. 67:1456-1462, 1989.

2. Chang, S.K.W., W.R. Santee, J.A. Devine and R.R. Gonzalez. The effect of hypobaric pressure on convective heat transfer. USARIEM Technical Report No. T/12, 1989.

3. Cymerman, A., J.T. Reeves, J.R. Sutton, P.B. Rock, B.M. Groves, M.K. Malconian, P.M. Young, P.D. Wagner and C.S. Houston. Operation Everest II: Maximal oxygen uptake at extreme altitude. J. Appl. Physiol. 66:2446-2453, 1989.

4. Delany, J.P., D.A. Schoeller, R.W. Hoyt, E.W. Askew, M.A. Sharp. Energy expenditure by doubly labeled water in soldiers during a field trial. J. Appl. Physiol. 67:1456-1462, 1989.

5. Forte, V.A., M.K. Malconian, R.L. Burse, P.B. Rock, P.M. Young, L.A. Trad, B. Ruscio, J.R. Sutton, C.S. Houston and A. Cymerman. Operation Everest II: Comparison of four instruments for measuring blood oxygen saturation. J. Appl. Physiol. 67:2135-2140, 1989.

6. Forte, V.A., J.A. Devine and A. Cymerman. A reusable adapter for collection of cerebrospinal fluid in chronically cannulated goats. Lab. Anim. Sci. 39:433-436, 1989.

7. Forte, V.A., J.A. Devine and A. Cymerman. A reusable adapter for collection of cerebrospinal fluid in chronically cannulated goats. USARIEM Technical Report No. T/9, 1989.

8. Fulco, C.S., P.B. Rock, J.T. Reeves, L.A. Trad, P.M. Young and A. Cymerman. The effects of propranolol on acute mountain sickness (AMS) and well-being at 4300 meters altitude. Aviat. Space Environ. Med. 60:679-683, 1989.

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PUBLICATIONS

9. Fulco, C.S., A. Cymerman, J.T. Reeves, P.B. Rock, L.A. Trad, P.M. Young and M.A. Hameed. Propranolol and the cardiocirculatory compensatory responses to upright tilt at high altitude. Aviat. Space Environ. Med. 60:1049-1055, 1989.

10. Fulco, C.S., P.B. Rock, L.A. Trad, M.S. Rose, V.A. Forte, P.M. Young and A. Cymerman. The effect of caffeine on endurance time to exhaustion at high altitude. USARIEM Technical Report No. T/17, 1989.

11. Green, H.J., J.R. Sutton, P.M. Young, A. Cymerman and C.S. Houston. Operation Everest II: Muscle energetics during maximal exhaustive exercise. J. Appl. Physiol. 66:142-150, 1989.

12. Green, H.J., J.R. Sutton, A. Cymerman, P.M. Young and C.S. Houston. Operation Everest II: Adaptations in human skeletal muscle. J. Appl. Physiol. 66:2454-2461, 1989.

13. Morgan, T.E., L.A. Hodges, D. Shilling, R.W. Hoyt, E.J. Iwanyk, G. McAninch, T.R.C. Wells, V.S. Hubbard, E.W. Askew. A comparison of the meal ready-to-eat, ration cold weather, and ration lightweight nutrient intakes during moderate altitude cold weather field training operations. USARIEM Technical Report No. T/5, 1989.

14. Stein, T.P., R.W. Hoyt, M. O'Toole, M.J. Leskiw, M.D. Schluter, R.R. Wolfe and W.D.B. Hiller. Protein and energy metabolism during prolonged exercise in trained athletes. Int. J. Sports Med. 5:311-316, 1989.

15. Young, P.M., J.R. Sutton, H. Green, J.T. Reeves, A. Cymerman and C.S. Houston. Operation Everest II: Plasma lipid and hormonal responses during a simulated ascent of Mt. Everest. J. Appl. Physiol. 66:1430-1435, 1989.

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ABSTRACTS:

16. Baker, C.J., P.B. Rock, C.S. Fulco, L.A. Trad and A. Cymerman. High-Altitude-Induced Anorexia. FASEB J. 48:A987, 1989.

17. Forte, V.A., J.A. Devine and A. Cymerman. Ventilatory response to prolonged hypercapnic hypoxia in rats. FASEB J. 3:5407, 1989.

18. Fulco, C.S., P.B. Rock, L.A. Trad, M.S. Rose, V.A. Forte, P.M. Young and A. Cymerman. The effect of caffeine (CAF) on endurance time to exhaustion (ETX) at high altitude. FASEB J. 48:A987, 1989.

19. Hamilton, A.J., L.A. Trad and A. Cymerman. Alterations in upper extremity motor function during hypoxic exposure. Sixth International Hypoxia Symposium. Banff, Alberta, Canada, February, 1989.

20. Hoyt, R.W., T.P. Stein, H.R. Lieberman, T.E. Morgan, E.J. Iwanyk, E.W. Askew and A. Cymerman. Doubly labeled water (DLW) method accurately estimates energy expenditure during field operations. Sixth International Hypoxia Symposium. Banff, Alberta, Canada, February, 1989.

21. Hoyt, R.W., E.W. Askew, J.P. Delany, D.a. Schoeller, V.S. Hubbard. Use of the doubly labeled water energy expenditure technique to evaluate combat rations and soldier performance in the field. Proceedings of Fourth Conference of Federally Supported Human Nutrition Research Units, Bethesda, MD, February 1989.

22. Kamimori, G.H., R.W. Hoyt, P.M. Young, V.A. Forte, A. Cymerman and M.J. Durkot. Chronic altitude affects hepatic blood flow and caffeine metabolism in miniature swine. Med. Sci. Sports Exerc. 21:S62, 1989.

ALTITUDE RESEARCH DIVISION

ABSTRACTS:

23. Lieberman, H.R., E.W. Askew and R.W. Hoyt. Changes in plasma tyrosine and other amino acids due to consumption of a calorie deficient diet for 30 days. FASEB J. 3:A463, 1989.

24. Meehan, R.T., N.M. Cintron, W.J. Kraemer, P.B. Rock and A. Cymerman. Association between ACTH and beta endorphin levels an susceptibility to acute mountain sickness. Aviat. Space Environ. Med. 50:482, 1989.

25. Morgan, T.E., R.W. Hoyt, M.J. Durkot, J.L. Briggs, M.S. Rose and E.W. Askew. Metabolic effects of supplementing a hypocaloric diet with fat. FASEB J. 3:A448, 1989.

26. Sutton, J.R., J.T. Reeves, B.M. Groves, P.D. Wagner, P.M. Young, H.J. Green, A. Cymerman and C.S. Houston. Sites of limitation to exercise performance to extreme altitude. International Congress of Physiological Sciences, Helsinki, Finland, 1989.

PRESENTATIONS:

27. Fulco, C.S., P.B. Rock, L.A. Trad, M.S. Rose, V.A. Forte, P.M. Young and A. Cymerman. The effect of caffeine (CAF) on endurance time to exhaustion (ETX) at high altitude (HA). Federation of American Society for Experimental Biology, 73rd Annual Meeting, New Orleans, LA March, 1989.

28. Fulco, C.S. The effect of acute and prolonged altitude exposures on maximal and submaximal physical performances. Current Concepts in Environmental Medicine. Natick, MA May 1989.

29. Hoyt, R.W. Use of Doubly Labeled Water Energy Expenditure Technique to Evaluate Combat Rations and Soldier Performance in the Field. Fourth Conference of Federally Supported Human Nutrition Research Units and Centers, National Institutes of Health, Bethesda, MD, February, 1989.

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PRESENTATIONS:

30. Hoyt, R.W. Doubly Labeled Water (DLW) method accurately estimates energy expenditure during field operations. Sixth International Hypoxia Symposium, Banff, CDA, February, 1989.

KEY BRIEFINGS:

31. A. Cymerman, Ph.D. Medical and practice problems of military operations at high altitude in Bolivia. Ft. McPherson, GA, March, 1989.

32. A. Cymerman, Ph.D. Army ration testing and nutrition at altitude. DoD Military Mountaineering Symposium, Marine Mountain Warfare Training Center, Bridgeport, CA April, 1989.

33. A. Cymerman, Ph.D. Medical and practice problems of military operations at high altitude in Bolivia. North Carolina Air National Guard, Fuerte Caminos, April, 1989.

34. A. Cymerman, Ph.D. Medical and practice problems of military operations at high altitude in Bolivia. U.S. Army School of Aviation Medicine, Ft. Rucker, AL, July, 1989.

35. A. Cymerman, Ph.D. High altitude medical problems. U.S. Army School of Aviation Medicine, Ft. Rucker, AL, October, 1989.

36. A. Cymerman, Ph.D. Lessons learned from Fuertes Caminos 89, Task Force, Ft. Riley, KS, November 1989.

37. E.J. Iwanyk, MAJ. Medical problems at high terrestrial elevation, U.S. Army School of Aviation Medicine, Ft. Rucker, AL, February, 1989.

38. E.J. Iwanyk, MAJ. Medical problems at high terrestrial elevation, U.S. Army South Command Surgeon and Commanders of the 536th Engineer Battalion and 142d Medical Battalion, Fort Kobbe, Panama, June, 1989.

ALTITUDE RESEARCH DIVISION

SIGNIFICANT TDY:

A. Cymerman, Ph.D. To attend Banff Hypoxia Symposium, Banff, Alberta, CDA, February 1989.

R.W. Hoyt, Ph.D. To conduct Mt. Rainer, Washington study, Seattle, WA March, 1989

R.W. Hoyt, Ph.D. Attended Symposium on "Use of Carbohydrate-Electrolyte Replacement Beverages by Soldiers in the Field," Food and Nutrition Board's Committee on Military Nutrition Research, National Academy of Sciences, Washington, D.C., February 1989.

E.J. Iwanyk, MAJ. Task Force Surgeon for the Joint Combined Task Force Bolivia participating in Exercise Fuerzas Unidas Bolivia 89, Panama and Bolivia, June - July 1989.

SIGNIFICANT VISITORS

Russell C. Eberhard. Program Manger, Biomedical Programs Office, The John Hopkins University Applied Physics Laboratory, Baltimore, MD, December, 1989.

Dr. Subash Manchanda, Professor of Cardiology. All India Institute of Medical Sciences, New Delhi, India, February, 1989.

Dr. N.D. Menon, Defense Institute of Physiology and Allied Sciences, New Delhi, India, October 1989.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

R.L. Burse, Sc.D. Judge, Massachusetts State Science Fair, M.I.T. May, 1989. R.C.B. Scd. Reviewed, Human Factors, (Journal of the Human Factors Society) and J. Appl. Physiol.

ALTITUDE RESEARCH DIVISION

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

R.W. Hoyt, Ph.D. Co-Chair and organizer of 1989 Hypoxia Interest Group meeting. The American Physiological Society Council approved the formation of an APS Hypoxia Interest Group in March, 1989.

COLD RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. The ability to use the Ration, Cold Weather in Company size training operations was tested by comparing two squads (one with supplemental water and one supplied normally) during a normal winter operation in Alaska. Both groups were moderately hypohydrated and the consumption of the ration was not acceptable for either group. One group lost 3.2% of body weight while the other lost 4.1% (acceptable weight loss should not exceed 3.0%). This study illustrated the need for individual stoves for troops using the Ration, Cold Weather or to face the problems of inadequate food consumption and possible hypohydration. (Publications: 8)

2. Exposure of troops to a cold environment results in reduced plasma volumes. Fluid shifts during cold exposure at rest in a supine position were examined. The measurement of chloride in plasma and urine allowed the calculation of intracellular, extracellular, and interstitial chloride spaces according to the Donnan Factor. Our results have indicated an intracellular fluid shift during a four hour cold exposure (60° F). We have also observed a significant negative change in plasma volume as well as significant cold induced diuresis during cold exposure. These results suggest that the negative change in plasma volume observed during four hours at 60° F occurs from both a cold induced diuresis as well as an increased intracellular volume.

3. Early diagnosis of stress injuries in soldiers during training would permit earlier treatment and limit the severity of the injury. This would decrease the number of man hours lost due to injury and would reduce the burden on troop medical facilities. Infrared thermography may provide an early diagnosis of stress injuries. Thermographic data was collected from 1400 soldiers at Ft. Bliss, TX. This study will evaluate the effectiveness of infrared thermography as an early diagnostic indicator of stress fractures and other soft tissue injuries which cannot easily be defined radiographically. Data analysis is in progress.

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

4. Elevated plasma fibronectin (PF) level correlates with thermotolerance in animal models. Moreover, mean PF level is significantly elevated in soldiers after completion of exercise programs designed to improve their thermotolerance or physical performance. These findings indicate a potential for PF level as a marker for changes in thermotolerance. Since it is generally assumed that thermotolerance is modulated by seasonal change, studies were initiated to determine if human PF level also reflected such fluctuations. Seven human subjects, after giving their informed consent, provided blood samples for PF, albumin, fibrinogen, and globulin determinations in the spring, summer and fall. In addition, their blood volume, plasma volume and thermotolerance were determined. Testing of the samples from the spring and summer studies has been completed. Data analysis is continuing. Preliminary findings indicate that mean PF level, blood volume and plasma volume significantly increased in the summer relative to the values determined in the spring. Since an increased blood and plasma volume is associated with thermotolerance, these early findings suggest a positive correlation between PF level and elevated thermotolerance. However, any conclusions await further comparisons with the winter studies.

5. It has been suggested that place of origin and ethnic background contribute to cold injury. Infrared thermographic data was collected during the Bering Bridge expedition on people indigenous to Arctic habitats, in the USSR and Alaska. Data was also collected on both Russian and American members of the expedition. The purpose of the study was to compare peripheral bloodflow patterns in individuals of Artic ancestral origins (American and Russian Eskimos) with non-native subjects, and compare expedition team members examined before and after prolonged cold exposure. These studies will provide information on identifing cold sensitive populations and on adaptation in cold environments.

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6. Injuries to the soldier's feet often relate to the presence of moisture in the boot. A study of pedal sweat reduction with use of antiperspirants was completed. Perspiration was equally distributed between sock and boot in both controls and treated groups. A 50 to 60 percent reduction in sweat accumulation was achieved with the two antiperspirants tested. A reduction in blisters was also noted among subjects using an antiperspirant.

7. A number of predisposing and environmental factors contribute to the incidence of frostbite for troops exposed to subfreezing temperatures. However, the outcome relates primarily to microvascular patency. Changes in the vascular patency of rat hindpaws cooled to four different subzero temperatures were evaluated. Left hindpaws of anesthetized rats in group one were cooled to -5°C, in group two to -15°C without freezing, in group three to the initiation of ice crystal formation as indicated by the release of latent heat of fusion (HOF), and in group four to HOF and then to -15°C. Cooled hindpaws were rapidly rewarmed; right hindpaws served as controls. Microvascular corrosion casts, which replicate patent vascular beds, were made from left and right hindpaws of all animals. There was no significant difference when mean cast weights of cooled hindpaws from groups one, two, and three were compared to mean cast weights of their respective control hindpaws. In group four, there was a significant difference ($p<0.5$) when the mean cast weight of cooled hindpaws (47.69mg $\pm$ SEM 9.05) was compared to that of control hindpaws (80.63mg $\pm$ 12.23). Since, in this acute experiment, a loss of vascular integrity occurred when hindpaws in group four were cooled to -15°C after reaching HOF, the initiation of freezing alone, as in group three, was not sufficient to reduce mean cast weight. (Abstracts: 9)

8. The potential for rapid deployment of troops from a warm environment to extremely cold areas increases the risk of cold induced injuries. Medical care for cold induced injuries can place a significant burden on the units and on their ability to

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perform their mission. Two features associated with attempts to rewarm human hypothermic victims, identified by the Medical After Action Conference on the Mount Hood tragedy (Report # T10-88), are the copious volume of fluid required during bypass rewarming, and the resulting edema. Such findings suggest mark alterations in the barrier function of the endothelium following cold exposure. Various endothelial cell (EC) metabolites and cytoskeletal elements influence permeability of this tissue. EC prostacyclin (PGI_2) is a major eicosanoid metabolite that affects permeability by its enhancement of F-action stress fibers. Such structures provide the tensile forces that support junctional integrity between ECs. PGI_2 also sustains EC barrier function by its inhibitory action on platelet-mediated elements that tend to increase permeability. Thromboxane (Tx) is an EC eicosanoid metabolite that reduces barrier function by its disruption of EC stress fibers and aggregation of platelets. Little is known of the effects of cold on EC eicosanoid metabolism and actin stress fibers. When bovine aortic ECs were exposed (2h) to 24°C, they generated similar levels of eicosanoid metabolites as those at 37°C. However, when they were rewarmed to 37°C, both PGI_2 and Tx synthesis were significantly elevated. Moreover, there was a significant shift in the Tx/PGI_2 ratio to one that was more prothrombogenic. Following cold treatment, ECs bound significantly greater quantities of phalloidin, a specific probe for F-actin. Photomicrographs indicated that enhanced binding was perhaps the result of stress fiber disruption, which led to the exposure of additional F-actin binding sites for phalloidin. These findings suggest that the enhanced permeability associated with the rewarming of human hypothermic victims could be explained, in part, by the direct effects of cold on EC function. Such EC models may contribute to our understanding of cold pathophysiology and lead to measures that support EC function in soldiers subjected to cold environments. (Presentations: 12)

9. Cold weather injuries can have major impact on military performance due to the extended recovery period, the development

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of cold sensitivity after an initial injury, and the cost of medical care. Both frostbite and hypothermia induce changes in cell permeability which contribute to the outcome of cold injury, and generalized edema results from severe hypothermia. The isolated perfused rat liver was used to determine the effects of ischemia and hypothermia on endothelial and parenchymal cell permeability, and on their ultrastructure. Leakage of potassium and aspartate aminotransferase, bile production, ammonia accumulation, and ultrastructure were used as indicators of cell injury. After an initial 15 minute perfusion at 24° C, the circulating perfusate bypassed the liver for 120-135 minutes, followed by a 45 minutes reflow, before elevations in aspartate aminotransferase and potassium were evident. Bile production ceased after the onset of ischemia and never recovered. Ischemic or reflow injury was evident at the ultrastructural level in the samples exposed for 135 minutes to ischemia, but exposure for 120 minutes resulted in inconsistent ultrastructural changes. A demonstration of a commercially available "Living Skin Equivalent," a multilayered skin substitute, prepared from human fibroblasts and keratinocytes, suggests that this "test skin" may be useful in some aspects of frostbite research. This artificial skin was designed as a replacement for animal skin in toxicity testing.

PUBLICATIONS:

1. Ahle, N.W., J.R. Buroni, M.W. Sharp, and M.P. Hamlet. Infrared thermographic measurement of circulatory compromise in trenchfoot injured Argentine soldiers. Aviat. Space Environ. Med. (In Press).

2. Daum, P.S., W.D. Bowers, Jr., J. Tejada, D. Morehouse, and M.P. Hamlet. An evaluation of the ability of the peripheral vasodilator buflomedil to improve vascular patency after acute frostbite. Cryobiology 26:85-92, 1989.

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PUBLICATIONS:

3. DuBose, D.A., L. Armstrong, W. Kraemer, and M. Lukason. Modulation of human plasma fibronectin levels following exercise. Aviat. Space Environ. Med. 60:241-245, 1989.

4. DuBose, D.A., D. Shepro, and H.B. Hechtman. Modulation of phospholipase A_2 activity by actin and myosin. Inflammation. 13:15-29, 1989.

5. Edwards, J.S.A., D.E. Roberts, T.E. Morgan, and L.S. Lester. An evaluation of the nutritional intake and acceptability of the meal, ready-to-eat consumed with and without a supplemental pack in a cold environment. USARIEM Technical Report No. T/18-89, 1989.

6. Hamlet, M.P., D.F. Danzl, and R.S. Pozos. Hypothermia. In: Management of Wilderness Environmental Emergencies. R.S. Auerbach and E.C. Geehr. (Eds.). C.V. Mosby, St. Louis, 1989, pp. 35-76.

7. Jackson, R.J., D.E. Roberts, R.A. Cote, P. McNeal, J.T. Fay, M.W. Sharp, E. Kraus, and M.P. Hamlet. Psychological and physiological responses of Blacks and Caucasians to hand cooling. USARIEM Technical Report No. T/20-89, 1989.

8. Roberts, D.E., B.J. McGuire, D.B. Engell, C.A. Salter, and M.S. Rose. The role of water consumption on consumption of the ration, cold weather. USARIEM Technical Report No. T/13-89, 1989.

ABSTRACTS:

9. Daum, P., W. Bowers, Jr., J. Tejada, and D. Morehouse. Cooling to heat of fusion (HOF) does not reduce vascular cast size. FASEB J. 3:A395, 1989.

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ABSTRACTS:

10. Jackson, R.L., D.E. Roberts, J. Scheetz, and J. Bannister. Physiological response to hand cooling. FASEB J. 3:A395, 1989.

PRESENTATIONS:

11. Agnew, J.W. and D.A. DuBose. Seasonal variation in plasma volume changes during submaximal exercise at 20°C and 35°C. Countering Space Adaptation with Exercise: Current Issues. National Aeronautics and Space Administration, Johnson Space Center, Houston, TX, September, 1989.

12. DuBose, D.A., D. Shepro, and H.B. Hectman. Effect of bovine aortic endothelial cell (BAEC) F-actin arrangement on bradykinin (BK) stimulation of prostacyclin (PGI_2). American Society for Cell Biology and the American Society for Biochemistry and Molecular Biology. San Francisco, CA, February, 1989.

KEY BRIEFINGS:

13. Neil W. Ahle, CPT, VC. Cold Weather Injury and Prevention; Wyoming National Guard, Casper, WY, January, 1989.

14. James W. Agnew, Ph.D., CPT, MS. Exercise in Environmental Extremes; 1989 U.S. Army Health Promotion Conference, Personal Readiness Division, Office of the Surgeon General, San Antonio, TX, September, 1989.

15. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention; C Squadron, Fort Bragg, NC, January, 1989.

16. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention; New England Regional Commanders, Mountain Warfare School, Vermont National Guard, Jericho, VT, January, 1989.

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KEY BRIEFINGS:

17. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention; 2nd Ranger Battalion, Fort Lewis, WA, January, 1989.

18. Murray P. Hamlet, D.V.M. Cold Weather Operations; Mountain Warfare School, Vermont National Guard, Jericho, VT, February, 1989.

19. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention; Commanders, MEDDACS, and Key Cadre, Fort Bragg, NC, February, 1989.

20. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention; Competition of Skiers Militaire, Mountain Warfare School, Vermont National Guard, Jericho, VT, March, 1989.

21. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention; Army Flight Surgeons Primary 16 Course, 89-2, Fort Rucker, AL, March, 1989.

22. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention; Command and General Staff College, Fort Leavenworth, KS, April, 1989.

23. Murray P. Hamlet, D.V.M. Brief CAC Northern Operations Working Party (6th ID), Fort Leavenworth, KS, May, 1989.

24. Murray P. Hamlet, D.V.M. Brief on Winter Warfare, 11th Special Forces Group (A), West Point, NY, June, 1989.

25. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention, Army Flight Surgeons Course, Camp A.P. Hill, VA, July, 1989.

26. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention, 22nd Infantry, Fort Drum, NY, October, 1989.

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KEY BRIEFINGS:

27. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention, Army Flight Surgeons Primary 16 Course, 90-1, Fort Rucker, AL, October, 1989.

28. Murray P. Hamlet, D.V.M. Briefing on Cold Injury to the Training Cadre, Fort Dix, NJ, November, 1989.

29. Murray P. Hamlet, D.V.M. Brief the F.B.I. Hostage Rescue Team on Cold Injury, Quantico, VA, November, 1989.

30. Murray P. Hamlet, D.V.M. Cold Weather Injury, Prevention, and Treatment, Physicians, Nurses and MEDDAC, Fort Benning, GA, November, 1989.

31. Murray P. Hamlet, D.V.M. Cold Weather Injury and Prevention, MEDDAC group, Fort Campbell, KY, December, 1989.

32. Donald E. Roberts, Ph.D. Status of Hydration of Troops During Field Training; BG Evensen, Dep Commander, 6th ID, Fort Wainwright, AK, March, 1989.

SIGNIFICANT TDY:

James W. Agnew, CPT. To attend the Annual Conference of American College of Sports Medicine, Baltimore, MD, 31 May - 3 June, 1989.

James W. Agnew, CPT. To attend a Conference on Countering Space Adaptation with Exercise: Current Issues, Houston, TX, September, 1989.

Wilbert D. Bowers, Ph.D. To attend Federation of American Societies for Experimental Biology, New Orleans, LA, 19-23 March, 1989.

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SIGNIFICANT TDY:

Andre A. Darrigrand, MAJ. To attend Infectious Diseases of Laboratory Animals: Recent Update, Cambridge, MA, June, 1989.

Andre A. Darrigrand, MAJ. To attend Dermatology Update, W. Springfield, MA, August, 1989.

Andre A. Darrigrand, MAJ. To attend Charles River Symposium on Swine in Biomedical Research, Danvers, MA, September, 1989.

Andre A. Darrigrand, MAJ. To attend Conference of the American Association of Laboratory Animal Science, Little Rock, AK, October/November, 1989.

Patricia S. Daum, M.A. To attend Federation of American Societies for Experimental Biology, New Orleans, LA, 19-23 March, 1989.

David A. DuBose, Ph.D. To attend combined annual meeting of the American Society for Cell Biology and the American Society for Biochemistry and Molecular Biology, San Francisco, CA, February, 1989.

David A. DuBose, Ph.D. To attend the UCLA Symposium on the Molecular Biology of the Cardiovascular System, Keystone, CO, 10-17 April, 1989.

Murray P. Hamlet, D.V.M. To attend symposium about military clothing during winter conditions, The Army Garrison in Ostersund, Sweden, 20-24 February, 1989.

Murray P. Hamlet, D.V.M. and SSG M.W. Sharp. To conduct infrared thermography evaluation on team members of the joint USA/USSR Bering Bridge Expedition, Provideniya, Siberia, 28 March - 6 April, 1989.

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SIGNIFICANT TDY:

Murray P. Hamlet, D.V.M., SSG M.W. Sharp, and SGT K. Speckman. To conduct infrared thermography evaluation on team members of the joint USA/USSR Bering Bridge Expedition in Kotzebue, AK and evaluation of soldiers at Fort Wainwright, AK, 2-12 May, 1989.

Murray P. Hamlet, D.V.M. To review thermography study at Fort Bliss, TX, 2-5 November, 1989.

Donald E. Roberts, Ph.D. To collect data on hydration status and food intake for the study "An evaluation of the nutritional intake and acceptability of the meal, ready-to-eat consumed with and without a supplemental pack in a cold environment", Fort Greely, AK, 24 February-19 March, 1989.

Donald E. Roberts, Ph.D. To collect data for the protocol "Classical conditioning as a treatment for injury induced cold intolerance", Fort Wainwright, AK, August - November, 1989.

D. Scott, CPT, SSG M. Sharp, SGT K. Speckman, SPC R. Cote, SPC D. Glass, SPC M. Shelby, SPC W. Masiker, PFC J. Shoda, and C. Melvin. To collect thermographic data on stress fractures and other soft tissue injuries of the lower extremities, Fort Bliss, TX, June - December, 1989.

M. Sharp, SSG and SGT K. Speckman. To attend Infrared Thermography seminar in San Diego, CA, 20-25 February, 1989.

M. Sharp, SSG and SGT K. Speckman. To attend 01H conference in Baltimore, MD, 6-9 June, 1989.

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EXERCISE PHYSIOLOGY DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Light Infantry soldiers carry an average 40 kg total load in training exercises and may carry as much as 74 kg in a worst case situation. We conducted a study to determine the weekly frequency of load carriage training needed to improve load carriage performance and to examine physiological factors related to load carriage. Soldiers were initially assessed for aerobic capacity, anaerobic capacity, body composition and muscle strength. They were split into 4 groups and participated in a 9 week physical training program designed to improve load carriage. The 4 groups differed only in the amount of road marching performed: either 0, 1, 2 or 4 times per month. Before and after the training program they performed a maximal effort 20 km road march carrying a total load of 46 kg. Load carriage training twice a month produced post-training road march times equivalent to training 4 times per month. Groups performing load carriage training 2 or 4 times per month were faster on the post-training than groups training once a month or less. A variety of muscle strength measurements as well as aerobic capacity and fat free body weight had low but statistically significant correlations with road march time. Significant decrements in marksmanship and maximal grenade throwing distance were found after both the pre-training and post-training road march. (Key Briefings: 67,68)

2. To determine the physiological and perceptual responses to prolonged load-carriage, 15 male soldiers walked on a treadmill for a distance of 12 km at speeds of 3.96, 4.86, and 5.76 km/hr in both the unloaded condition (clothing wt of 5.2 kg) and with external loads of 31.5 and 49.4 kg (load-carriage equipment + backpack). In addition, the ability to perform high intensity, anaerobic exercise immediately after load carriage as well as a comparison in the energy cost between wearing the Army's external frame pack system (ALICE) and the new internal frame system (IIFS) were determined. Oxygen uptake ($\dot{V}O_2$), minute ventilation ($\dot{V}E$), heart rate, and differentiated ratings of perceived exertion (RPE) were assessed at the end of the first 10 min and every 20 min thereafter for every trial. A 10 min rest period was allowed each hour. At the end of each trial blood samples were taken for the measurement of lactate and subjects performed either an upper or lower body

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anaerobic power test. No changes occurred in $\dot{V}O_2$ over time in the unloaded condition at any speed. The 31.5 and 49.4 kg loads, however, produced significant increases at the two fastest and at all three speeds, respectively. Similar results were also seen for $\dot{V}E$, heart rate and RPE's. Following load carriage, no significant differences were found in either upper or lower body power outputs as measured by the Wingate test. In addition, no significant differences were seen in blood lactate levels with respect to either speed or load. Finally, no significant differences were found in any of the physiological or perceptual responses between the external or internal frame pack systems. It can be concluded, therefore, that (a) energy cost during prolonged load-carriage is not constant but increases over time even at relative intensities below 30% $\dot{V}O_2max$, (b) the load-carriage conditions of this study were not sufficient to cause physical fatigue as assessed by blood lactate levels and maximal power outputs, and (c) the two load-carriage systems did not differ as to their effects on the physiological and perceptual responses to heavy load-carriage. (Abstracts: 34)

3. The study entitled Energy cost of 155 mm Howitzer operation and physiological factors in sustained operations (HURC #393) was conducted at Ft. Sill, OK during the period 27 November through 8 December 1989. Twelve soldiers participated in all the pre-scenario measurements. Two crews of five soldiers each participated in one 48 hour scenario. The soldiers rotated through five positions every 1-1/2 hours; 2 in the supply vehicle, 1 as #1 man (loading the rounds), and 2 were in a resting phase. During each scenario, one soldier was lost due to a minor injury. Supporting soldiers were provided from their unit as follows: 1 crew chief for each group, 3 gunners, and 6 additional personnel to assist in operation of the simulator. Preliminary results indicate that vigor decreased and fatigue increased during the scenario, as measured by a POMS. There was also a significant increase in general muscle soreness during the scenario. The metabolic data is still being reduced, therefore, no estimates of energy cost during the scenario are available. That the soldiers were able to maintain an acceptable level of performance indicated

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that high rates of fire can be maintained for a 48 hour period. The metabolic data can be used to evaluate nutritional needs of the soldiers, and to model performance in various environments. No data of this kind are currently available.

4. The primary cause of morbidity in the peacetime Army is injuries. Training and physical activity related injuries have been studied among the basic trainees, however, there is little reliable injury data on combat ready troops. A survey of injuries is presently being conducted on new cohorts of light infantry battalions at Ft. Drum, NY (February 1989-1990) and Ft. Ord, California (August 1989-1990). Among the Ft. Drum infantry troops, approximately 12% per month incur one or more musculoskeletal training injuries. These rates seem high but they are less than seen in the basic trainee population (25%). The rate of lost duty days per 100 trained soldiers per month is 114 days and stress fractures are the injuries causing the greatest amount of lost duty. We plan to further improve the standardization of methods of diagnosis and treatment of training related injuries. Secondly, the data from the injury studies should provide us with information about risk factors (i.e., level of fitness, training design) that would be important in developing preventive strategies for injury occurrence. (Key Briefings: 65)

5. A study was designed to longitudinally examine the influence of body composition measures (body mass index and Army circumference equation assessed percent body fat) on success of new Army recruits. This involved a mail survey to commanders of all active duty soldiers initially studied in the Fort Jackson injury study. Complete data from 367 male and 252 female soldiers, representing the non-pregnant and non-attrited sample, indicated that female recruits were more likely to exceed their fat standards when they entered the Army and, although they lost weight during basic training, females were also more likely to exceed their fat standards at their first unit, compared to males. Males and females who exceeded their fat standards did not perform as well on the APFT, either at the beginning of basic training or, even after significant improvement at the end of basic training. This

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relationship was stronger in the males and this is attributed to the narrow range of fatness in females permitted to enter the Army, relative to male soldiers. There was a trend toward a higher attrition rate for male recruits with increasing initial fatness, but because of the restricted female fat range, no such trend was apparent in females. However, females with a low body mass index were overrepresented in the attrited sample. These data suggest that it may be possible to adjust current accession standards for males, making them more stringent but still allowing a gap for the observed achievable fat loss with respect to retention standards. The female retention standards may already be unrealistically stringent, but without a study of fatter females, no predictions can be made about suitable standards. (Key Briefings: 57.58.59.61.66.70)

6. Between September and December 1989 a population of 1897 Army basic trainees (1027 males and 870 females, 13 companies, were followed prospectively over successive 8 week IET cycles. Baseline anthropometric, physical fitness and questionnaire (past health and physical activity) data were collected and then follow-up data on injuries, discharges and physical performance were gathered. The objectives of the study were to determine the relationships of % body fat (BF) and physical fitness on entry to the Army with subsequent risks of injury and discharge, as well as physical performance. Another objective was to determine the effect of unit level training on risk of injury. Preliminary analysis of data from 1 battalion (5 companies with 617 males and 437 females) indicate that there is little or no association between % BF and injury for males or females. However, body mass index (BMI) was associated with risk of injury for both males and females. Both the highest and lowest quintiles of BMI had higher risks. For females the risk ratio of the highest (fittest) quintile of BMI to the middle ("avg") was 1.4 (50%/36%) and for the lowest quintile of BMI (leanest) to the middle was 1.7 (60%/36%). For males the risk ratios were 1.3 (44%/33%) for low versus middle quintiles and 1.3 (43%/33%) for high to middle. Too few discharges occurred to test differences by degree of % BF statistically. In regard to training, it appeared that the companies doing the least total

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amount of running and marching had modestly lower risks of injuries requiring profiles for males. The risk of injury for the low mileage company of males was 16.9% (with 1 or more profiles) versus 22.4% and 25.1% for the 2 higher mileage companies. For females the risk for the low mileage company was 32.0% versus 35.3%. For males and females the lower running mileage companies performed just as well on the 2 mile run on the APFT test at the end of the cycle. Another finding in this battalion was that male and female companies that did no running in the 3rd week of training had significantly lower risks of early discharge from the Army. For males the risk of discharge for companies running every week was 4.2% versus 0.9% for those doing no running in the 3rd week, risk ratio = 4.6 (4.2%/0.9%). For females the risk of the company running every week was 7.9% versus 3.2% for those doing none in the 3rd week, risk ratio = 2.5 (7.9%/3.2%). (Abstracts: 30,32; Presentations: 47,48,49,50; Key Briefings: 62,63,64)

7. A prospective study of 1374 male Army basic trainees (6 companies) was conducted at Ft. Bliss, TX between July and December 1989. Subjects were prescreened and then followed for the occurrence of stress fractures and other injuries over the 8 week initial entry training (IET) cycle. Objectives were to determine: (a) if not running in the 2nd, 3rd or 4th week of IET reduces the incidence of stress fractures (stress fx), (b) the incidence of false positive bone scans in "normal" uninjured volunteers, and (c) the reliability of thermography in diagnosing training injuries. Injury sick call visit rates for the 6 companies averaged 27.4/100/mo (range: 11.5 to 41.3/100/mo). Stress fx visit rates averaged 3.4% (range: 0.74 to 6.2%). No running in the early weeks of training did not appear to reduce visit rates for stress fx. Average stress fx visit rates were: 7.1% for 3 test (no running) companies, 4.7% for 2 control companies, and 9.8% for 1 high mileage company. Among 234 "normal" uninjured volunteers bone scans done in the 7th week were positive at grade 1 or higher in 96%, in 60% grade 2 or higher, and in 14% grade 3 or above. Preliminary blinded readings of over 2000 thermograms are almost complete. The above crude data suggest that: (a) not running in the early weeks of IET will not by itself reduce stress fx rates

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and (b) bone scans are overly sensitive and not specifically diagnostic of stress fx (i.e., almost any trainee receiving a bone scan will be positive).

EXERCISE PHYSIOLOGY DIVISION

PUBLICATIONS:

1. Armstrong, L.E., R.P. Francesconi, W.J. Kraemer, N. Leva, J.P. DeLuca and R.W. Hubbard. Plasma cortisol, renin and aldosterone during an intense heat acclimation program. Int. J. Sports Med. 10:38-42, 1989.

2. DeLany, J.P., D.A. Schoeller, R.W. Hoyt, E.W. Askew and M.A. Sharp. Field use of $D_{2}{}^{18}O$ to measure energy expenditure of soldiers at different energy intake. J. Appl. Physiol. 67:1922-1929, 1989.

3. Harman, E., R. Rosenstein, P. Frykman and G. Nigro. The effects of a belt on intra-abdominal pressure during weightlifting. Med. Sci. Sports Exercise, 21(2):186-190, 1989.

4. Harman, E., M. Rosenstein, P. Frykman, R. Rosenstein. The effects of arms and countermovement on vertical jumping. Med. Sci. Sports Exercise. (In press).

5. Harman, E. Coming to terms: Biomechanical terminology. Natl. Strength and Conditioning Assn. J. (In press).

6. Friedl, K.E. Reappraisal of the health risks associated with the use of high doses of oral and injectable androgenic steroids. NIDA Monograph: Anabolic Steroid Abuse (In press).

7. Friedl, K.E., D. Pearson, C. Maresh, W. Kraemer, D. Catlin. What the coach, athlete, and parents need to know about anabolic drugs: a fact sheet. Natl. Strength and Conditioning Assn. J. 11:10-13, 1989.

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EXERCISE PHYSIOLOGY DIVISION

PUBLICATIONS:

9. Friedl, K.E., C. Hannan, Jr. P. Schadler, W. Jacob. Atropine Absorption after intramuscular administration with 2-Pralidoxime chloride by two automatic injector devices. J. Pharmaceutical Sc. Vol. 78, No. 9, Septmeber 1989.

10. Friedl, K.E., C. Hannan, Jr., R. Jones and S. Plymate. High-density lipoprotein cholesterol is not decreased if an aromatizable androgen is administered. Metabolism. (In press).

11. Friedl, K.E., C. Yesalis. Self-treatment of gynecomastia in bodybuilders who use anabolic steroids. The Phy and Sports Med, Vol 17, No. 3, March 1989.

12. Jones, B.H., J.M. Harris, T.N. Vinh, C. Rubin. Exercise-induced stress fractures and stress reactions of bone: Epidemiology, etiology and classification. In: Exer. and Sports Sci. Reviews. K. B. Pandolf (Ed.). Williams and Wilkins, Baltimore, 1989, pp 370-422.

13. Kraemer, W.J., L. Marchitelli, D. McCurry, B. Mello, J. Dziados, E. Harman, P. Frykman, A. Damokosh, C. Cruthirds, S. Gordon and S. Fleck. Hormonal and growth factor responses to heavy resistance exercise. J. Appl. Physiol. (In press).

14. Kraemer, W., J.F. Patton, H.G. Knuttgen, C.J. Hannan, T. Kettler, S.E. Gordon, J.E. Dziados, P.N. Frykman, E.A. Harman, and A.C. Fry. The effects of high intensity cycle exercise on sympatho-adrenal medullary response patterns. J. Appl. Physiol. (In press).

15. Kraemer, W.J., S.J. Fleck, R. Callister, M. Shealy, G. Dudley, C. Maresh, L. Marchitelli, C. Cruthirds, T. Murray, and J.E. Falkel. The effects of different run training programs on plasma responses of betaendorphin, adreno-corticotropin and cortisol to maximal treadmill exercise. Med. Sci. Sports Exercise. 21:146-153, 1989.

EXERCISE PHYSIOLOGY DIVISION

PUBLICATIONS:

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18. Knapik, J., J. Wright, M. Welch, M. Sharp, R. Mello and J. Patton. Metabolic and cardiorespiratory parameters during three consecutive days of exhaustive running. J. Sports Med. Phy. Fitness (In Press).

19. Knapik, J., W. Daniels, M. Murphy, P. Fitzgerald, F. Drews and J. Vogel. Physiological factors in infantry operations. Eur. J. Appl. Physiol. (In Press).

20. Knapik, J. Loads carried by soldiers: historical, physiological, biomechanical and medical aspects. USARIEM Technical Report No. T19-89, 1989.

21. Kraemer, W.J., J.F. Patton, H.G. Knuttgen, L.J. Marchitelli, C. Cruthirds, A. Damokosh, E. Harman, and P. Frykman. Hypothalamic-pituitary-adrenal responses to short duration high intensity cycle exercise. J. Appl. Physiol. 66: 161-166, 1989.

22. Marlowe, B., W. Tharion, E. Harman and T. Rauch. New computerized method for evaluating marksmanship from Weaponeer printouts. USARIEM Technical Report T3/90, October, 1989.

23. Patton, J.F., J.A. Vogel, A.I. Damokosh, and R.P. Mello. Effects of continuous military operations on physical fitness capacity and physical performance. Work and Stress 3: 69-77, 1989

24. Patton, J.F., W.J. Kraemer, H.G. Knuttgen, and E.A. Harman. Factors in maximal power production and in exercise endurance relative to maximal power. Eur. J. Appl. Physiol. (In press).

EXERCISE PHYSIOLOGY DIVISION

PUBLICATIONS:

25. Sharp, M., E. Harman, B. Boutilier, M. Bovee and W. Kraemer. Effects of progressive resistance training on maximal repetitive lifting capacity. Ergonomics. (In press).

26. Tharion, W., E. Harman, W. Kraemer and T. Rauch. Effects of different resistance exercise protocols on mood states. J. Applied Sports Sci. Rsch. (In press).

27. Vogel, J.A. Fitness and activity assessments among U.S. Army Populations: Implications for NCHS General Population Surveys (Chapter 13). In: Assessing Physical Fitness and Physical Activity in Population-Based Surveys. T.F. Drury, Editor. Dept. of Health and Human Services Pub. No. 89-1253, Public Health Svc., Wash, D.C., 1989.

28. Vogel, J.A. and M.A. Sharp. High intensity repetitive lifting capacity. In: Manual Materiel Handling: Understanding and Preventing Back Trauma. Am. Indust. Hygiene Assoc. Monograph, 1989.

ABSTRACTS:

29. Backous, D.D., J.A. Farrow, K.E. Friedl. Assessment of pubertal maturity in boys using height and grip strength. Clin Res 37:167A, 1989.

30. Cowan, D.N., B. Jones, J. Robinson. Medial longitudinal arch height and risk of injury. Med. Sci. Sports Exercise. 21(2): S60, 1989.

31. Harman, E. An axial force transducer for a weightlifting bar. Proceedings of the American Society of Biomechanics 13th Annual Meeting, 216-217, 1989.

32. Jones, B.H., D. Cowan, J. Robinson, D. Polly, H. Berry. Clinical assessment of medial longitudinal arch from photographs. Med. Sci. Sports Exercise. 21(2): S60, 1989.

EXERCISE PHYSIOLOGY DIVISION

ABSTRACTS:

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34. Patton, J.F., J. Kaszuba, R.P. Mello, and K.L. Reynolds. Effects of external loading on the energy cost of prolonged treadmill walking. The FASEB J. 3: A988, 1989.

PRESENTATIONS:

35. Fleck, S.J., J. Falkel, E. Harman, W.J. Kraemer, P. Frykman, C.M. Maresh, L.L. Goetz, D. Campbell, M. Rosenstein, and R. Rosenstein. Cardiovascular responses during resistance training. American College of Sports Medicine, Baltimore, MD, May, 1989.

36. Friedl, K.E., R.E. Jones, C.J. Hannan, S.R. Plymate (1989). Exogenous androgen administration is not associated with impaired insulin secretion or impaired glucost tolerance. American Federation of Clinical Research, Carmel, CA.

37. Friedl, K.E. Current data on health risks associated with androgen use by athletes. National Consensus Meeting on Anabolic/Androgenic Steroids, National Task Force on Anabolic/Androgenic Steroids, Amateur Athletic Foundation, Los Angeles, CA, 30-31 July 1989.

38. Friedl, K.E. Reappraisal of the health risks associated with the use of high doses of oral and injectable androgenic steroids. NIDA Technical Review Meeting on Anabolic Steroid Abuse, Rockville, MD, 6-7 March 1989.

39. Frykman, P., M. Rosenstein, E. Harman, and M. Sharp. Prediction of power output during vertical jumps using body mass and flight time. American College of Sports Medicine, Baltimore, MD,May 89.

EXERCISE PHYSIOLOGY DIVISION

PRESENTATIONS:

40. Frykman, P., E. Harman, M. Rosenstein, and R. Rosenstein. A computerized instrumentation system for weight machines. National Strength and Conditioning Association. Denver, CO, May, 1989.

41. Frykman, P., M. Rosenstein, E. Harman, and R. Rosenstein. Differences between segmental limb masses derived by four methods. American Alliance of Health, Physical Education, Recreation and Dance, Boston, MA, April, 1989.

42. Harman, E., M. Rosenstein, P. Frykman, R. Rosenstein, and M. Johnson. Torque-velocity relationships for flexion and extension about the knee and elbow joints. National Strength and Conditioning Assoc., Denver, CO, May, 1989.

43. Harman, E., M. Rosenstein, P. Frykman and M. Johnson. Torque and power during accelerative movements about the knee and elbow joints, American College of Sports Medicine, Worcester, MA, November 1989.

44. Harman, E. An axial force transducer for a weightlifting bar. American Society of Biomechanics, Burlington, VT, September, 1989.

45. Harman, E., M. Rosenstein, P. Frykman, R. Rosenstein and W. Kraemer. Evaluation of the Lewis power output test. American College of Sports Medicine, Baltimore, MD, May, 1989.

46. Jones, B.H. USARIEM update on physical training, fitness, and injuries, Army Health Promotion Conference (OTSG sponsor). San Antonio, TX, 15 September 1989.

47. Jones, B.H. Epidemiology of musculoskeletal injuries associated with Army training. Armed Forces Epidemiology Board. Walter Reed Army Institute of Research, Washington, D.C., 26 May 1989.

48. Jones, B.H. The relationship of physical fitness to health and performance of soldiers. Lecture to residents and guests. Walter Reed Army Institute of Research, Washington, D.C., 23 May 1989.

EXERCISE PHYSIOLOGY DIVISION

PRESENTATIONS:

49\. Jones, B.H. Risk factors for musculoskeletal injuries associated with Army physical training. TRADOC Physical Training Conference., U. S. Army Physical Fitness School., Ft. Benjamin Harrison, Indianapolis, IN, 27 April 1989.

50\. Jones, B.H. The impact of physical fitness on the health of military personnel. Staff development conference, Moncrief Army Hospital, Ft. Jackson, S. C., 19 January 1989.

51\. Kraemer, W.J., J.F. Patton, H.G. Knuttgen, C.J. Hannan, T.M. Kettler, S.E. Gordon, J.E. Dziados, A.C. Fry, P.N. Frykman, A. Damokosh, and E.A. Harman. The effects of high intensity cycle exercise on plasma catecholamine and proenkephalin peptide F response patterns. First International Olympic Committee World Congress on Sports Sciences, Colorado Springs, CO, October, 1989.

52\. Maresh, C.M., W.J. Kraemer, S.J. Fleck, L.L. Goetz, E. Harman, P. Frykman, and J. Falkel. Effects of heavy resistance exercise on hemodynamic, stress hormone and fluid-regulatory factors. American College of Sports Medicine, Baltimore, MD, May, 1989.

53\. Rosenstein, M., E. Harman, P. Frykman, and M. Johnson. An inexpensive method for measurement of torque and power output during accelerative movement. National Strength and Conditioning Association, Denver, CO, May, 1989.

54\. Rosenstein, M., E. Harman, P. Frykman and R. Rosenstein. Vertical Jumping with and without a step prior to countermovement. American Alliance of Health, Physical Education, Recreation and Dance, Boston, MA, April, 1989.

55\. Sharp, M., M. Bovee, B. Boutilier, E. Harman, and W. Kraemer. Effects of weight training on repetitive lifting capacity. American College of Sports Medicine, Baltimore, MD, May, 1989.

EXERCISE PHYSIOLOGY DIVISION

KEY BRIEFINGS:

56. Karl E. Friedl, CPT, Ph.D. Invited discussant for John Shuster, M.D. presentation on "CNS effects of androgenic steroids". Psychiatry Conference, Massachusetts General Hospital, 1 September 1989.

57. Karl E. Friedl, CPT, Ph.D. Accession weight study. Briefing to MG Russell, HQ Medical R&D Command, Fort Detrick, MD. 3 November 1989.

58. Karl E. Friedl, CPT, Ph.D. Accession weight study. Briefing to MG LaNoue and BG Adams-Ender, Office of the Surgeon General, Falls Church, VA, 7 November 1989.

59. Karl E. Friedl, CPT, Ph.D. Accession weight study. Briefing to BG Stroup, Office of the Deputy Chief of Staff for Personnel, Pentagon, Washington, DC, 7 November 1989.

60. Bruce H. Jones, LTC, MD, MPH. Background for and design of stress fracture prevention and thermographic diagnosis studies. Basic Training Brigade (COL Tate and staff), Ft. Bliss, TX, 13 June 1989.

61. Bruce H. Jones, LTC, MD, MPH. The relationship of entry level percent body fat to physical performance and risks of injury and discharge during Army basic training. Directorate of Enlisted Accessions, Department of the Army (COL Jewell and staff), Pentagon, Arlington, VA, 27 March 1989.

62. Bruce H. Jones, LTC, MD, MPH. Debriefing of preliminary study results regarding physical training, fitness and injuries and discharges among Army trainees. Commanding General (MG Krause), Ft. Jackson, S. C., 23 February 1989.

EXERCISE PHYSIOLOGY DIVISION

KEY BRIEFINGS:

63. Bruce H. Jones, LTC, MD, MPH. The association of physical training with injuries and physical performance in basic trainees at Ft. Jackson. BCT Battalion Commanders Conference, Ft. Jackson, S.C., 23 February 1989.

64. Bruce H. Jones, LTC, MD, MPH. Debriefing on preliminary results of accession standards study bearing on relationship of physical training on risk of injury and discharge in Army basic trainees. Deputy Commander (BG Hansel), Ft. Jackson, S.C., 3 February 1989.

65. Katy L. Reynolds, MD. FORSCOM Unit Injury Protocol. Briefing to 9th Regiment, 1st Battalion Command (LID), Ft. Ord, CA, August 1989.

66. Karl E. Friedl, CPT, Ph.D.. Accession weight study. Briefing to MG Wheeler, U. S. Army Recruiting Command, Fort Sheridan, IL, 14 December 1989.

67. Joseph Knapik, CPT, Sc.D. Physical training and load carriage; 2nd Bn, 17th Infantry Regiment, 6th Infantry Division (Light), Ft Richardson, AK 1989.

68. Joseph Knapik, CPT, Sc.D. Soldier performance and road marching. MG Fields, Commander 6th Infantry Division (Light), Ft Richardson, AK 1989.

69. James A. Vogel, Ph.D. Physical fitness research. Advance Course, Army War College, Carlisle, PA 1 May 1989.

70. James A. Vogel, Ph.D. Accession weight study. Briefing to MG Carney, CG, HQ USAREC, Ft. Sheridan, IL. 10 January 1989.

71. James A. Vogel, Ph.D. and Karl E. Friedl, CPT. Issues concerning the DOD Directive on body composition standards and the Army body fat prediction equations. Briefing to BG Scotti, Office of the Surgeon General, Falls Church, VA, 22 November 1989.

EXERCISE PHYSIOLOGY DIVISION

SIGNIFICANT TDY:

Bruce H. Jones, LTC, MD, MPH. Supervision of conjoint studies (prevention of stress fractures... and the utility of thermographic injury diagnosis...), Ft. Bliss, TX, 11 July - 8 November 1989.

Bruce H. Jones, LTC, MD, MPH. Participation in Centers for Disease Control Workshop on "Youth risk behavioral surveillance", Washington, D.C., 10 August 1989.

Bruce H. Jones, LTC, MD, MPH and COL Margarete DiBenedetto. Protocol defense (The utility of thermography in the diagnosis of injury...), Human Use Review Organization, William Beaumont Army Medical Center, Ft. Bliss, TX, 9 May 1989.

Bruce H. Jones, LTC, MD, MPH and John M. Harris, MD. Stress fracture prevention study design, William Beaumont Army Hospital, Ft. Bliss, TX, 18 - 19 January 1989.

Bruce H. Jones, LTC, MD, MPH. Data collection and follow-up of subjects for enlisted accession standards study, Ft. Jackson, S.C., 5 January - 9 February 1989.

Joseph Knapik, CPT, Sc.D. and staff of fifteen. Field study to examine physical training to improve load carriage and factors affecting load carriage. Ft Richardson, AK, 3-16 April 1989 and 25 June-8 July 1989.

Joseph Knapik, CPT, Sc.D. and John Patton, Ph.D. Consult with Special Forces on load carriage for special operations. Ft Bragg, NC, 14 November 1989.

Marilyn Sharp, M.S. and CPT Joseph Knapik, Sc.D. and staff of four. Field study to determine energy cost of simulated howitzer operations. Ft Sill, OK, 26 November-9 December 1989.

Katy L. Reynolds, MAJ, MD. Conduct a prospective FORSCOM Injury Research Program on a light infantry division new cohort group, Ft. Drum, NY, February 15, 1989 - February 15, 1990.

EXERCISE PHYSIOLOGY DIVISION

SIGNIFICANT TDY:

Katy L. Reynolds, MAJ, MD. Conduct a prospective FORSCOM Injury Research Program on a light infantry division new cohort group, Ft. Ord, CA, August 1989 - August 1990.

Karl E. Friedl, CPT, Ph.D. Workshop participant at the Ninteenth Steenbock Symposium, "Osteoporosis: physiological basis, assessment, and treatment." University of Wisconsin, Madison, WI, 5-8 June 1989.

Karl E. Friedl, CPT, Ph.D.. Workshop participant at "Basic and clinical aspects of regional fat distribution." National Institutes of Health, Bethesda, MD, 11-13 September 1989.

James A. Vogel, Ph.D. Chaired NATO Research Study Group meeting on Biomedical Aspects of Military Training, San Diego, CA, 13-17 November 1989.

James A. Vogel, Ph.D. Chaired NATO Research Study Group meeting on Biomedical Aspects of Military Training. Copenhagen, Denmark, 25-29 September 1989.

SIGNIFICANT VISITORS

Maj Stephen Rudzki, M.D. Medical Officer, Royal Australian Army Medical Corps, 9 June 1989.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Katy L. Reynolds, MAJ, MD. Medical Advisor, U. S. Army Research Institute of Environmental Medicine, Natick, MA.

Karl E. Friedl, CPT, Ph.D. Member, Performance Enhancing Substance Abuse Committee, National Strength and Conditioning Association.

Karl E. Friedl, CPT, Ph.D. Reviewer, International Journal of Sports Medicine.

EXERCISE PHYSIOLOGY DIVISION

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Karl E. Friedl, CPT, Ph.D. Reviewer, Medicine and Science in Sports and Exercise.

Karl E. Friedl, CPT, Ph.D. Reviewer, National Strength and Conditioning Association Journal.

Karl E. Friedl, CPT, Ph.D. Reviewer, The Physician and Sportsmedicine.

Everett Harman, Ph.D. Adjunct Assistant Professor: Sargent College of Allied Health Professions, Boston University.

Everett Harman, Ph.D. Reviewer: Journal of Applied Physiology.

Everett Harman, Ph.D. Reviewer: Medicine and Science in Sports and Exercise.

Everett Harman, Ph.D. Reviewer: The Physician and Sports Medicine.

Everett Harman, Ph.D. Reviewer: Exercise and Sports Sciences Reviews.

Everett Harman, Ph.D. Reviewer: Ergonomics.

Everett Harman, Ph.D. Associate Editor: National Strength and Conditioning Association Journal.

Everett Harman, Ph.D. Associate Editor: Journal of Applied Sports Science Research.

Everett Harman, Ph.D. Member, Research Committee: National Strength and Conditioning Association.

Everett Harman, Ph.D. Member, Tests and Measurements Committee: National Strength and Conditioning Association.

EXERCISE PHYSIOLOGY DIVISION

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Everett Harman, Ph.D. Member, Awards Committee: New England American College of Sports Medicine.

John F. Patton, Ph.D. Associate Editor: Journal of Applied Sports Science Research.

James A. Vogel, Ph.D. Associate Editor: Journal of Applied Sports Science Research.

James A. Vogel, Ph.D. Adjunct Professor, Boston University.

James A. Vogel, Ph.D. Consultant to Department of Public Administration and the Criminal Justice Training Council, Commonwealth of Massachusetts.

James A. Vogel, Ph.D. Member, Secretary of the Army Physical Fitness Planning Committee.

James A. Vogel, Ph.D. Member, Army counterpart panel on Board of Army Science and Technology Study of Strategic Technologies (BAST-STAR).

James A. Vogel, Ph.D. Member, DoD Human Factors Engineering TAG Sustained/Continuous Operations Subgroup.

James A. Vogel, Ph.D. Chairman, NATO DRG Panel 8 Research Study Group-17 on Biomedical Aspects of Military Training.

James A. Vogel, Ph.D. Chairman, Credentials Committee, American College of Sports Medicine.

James A. Vogel, Ph.D. Member, Research Awards Committee, American College of Sports Medicine.

James A. Vogel, Ph.D. Member, Board of Trustees, New England Chapter of the American College of Sports Medicine.

HEALTH AND PERFORMANCE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. A study was conducted to evaluate the separate effects of standard dosages of antihistamines (terfenadine (60mg) and diphenhydramine (50mg)) on sentry duty performance as measured by the speed of detection of visually presented targets and rifle marksmanship. It is claimed that terfenadine does not have the central nervous system side effects (namely, sedation and disturbed coordination) that are associated with other antihistamines such as diphenhydramine. Using a double-blind Latin square design, 12 trained subjects were exposed to four separate test conditions over four separate test days: (a) control, (b) placebo (c) 60mg terfenadine, and (d) 50mg diphenhydramine. Each test session was three hours in duration, during which time the subject monitored the target scene of the Weaponeer M16A1 Rifle Marksmanship Simulator. When a target appeared, the subject pressed a key, lifted the rifle, aimed, and fired at the target. Speed of target detection was measured in terms of the time required by the subject to press the key. Marksmanship was measured in terms of number of hits. Regardless of drug condition, target detection time increased as time on the task increased. As compared to placebo and control conditions, 50mg diphenhydramine significantly degraded both target detection time and marksmanship; 60mg terfenadine had no effect on either of the dependent variables. The results of this study suggest that sentry duty performance may be optimized if soldiers are discouraged from using over-the-counter antihistamines such as diphenhydramine, which may cross the blood-brain barrier and cause sedation and disturbed coordination. (Publications: 6, 7; Presentations: 28, 29; Key Briefings: 35, 36, 37)

2. A study was conducted to assess the effects of three different clothing ensembles on the soldier's rifle marksmanship ability. Soldier performance on simple sensory and psychomotor tasks has been shown to be impaired by the bulkiness of combat clothing and equipment. Since rifle marksmanship is a complex task requiring the coordination of simple sensory and psychomotor skills, it was hypothesized that combat clothing would also impair this task which is so critical to successful soldier performance and survival.

HEALTH AND PERFORMANCE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

Each of 30 male soldier volunteers, matched on rifle marksmanship ability, was assigned to one of three clothing conditions of increasing bulk: battle dress uniform, fighting load, or MOPP-IV chemical protective clothing. After four days of practice on the Weaponeer M16 rifle simulator, soldiers were assessed on marksmanship for pop-up targets (in both rifle supported and unsupported conditions) while dressed in the respective combat clothing. Results of a 3 x 2 (clothing x rifle support) analysis of variance showed that (a) regardless of clothing condition, marksmanship was significantly better when the rifle was supported than when it was not supported; and (b) rifle marksmanship was significantly poorer under the MOPP-IV chemical protective clothing condition than under either the fighting load condition or the battle dress uniform condition. (Key Briefings: 37)

3. The potential for use of chemical weapons in future warfare demands that nerve agent antidotes be available for troops exposed to chemical attack. Since future combat operations will most likely occur in tropical and desert areas, chemical attacks in such areas could lead to situations involving the use of nerve agent antidotes by troops during exposure to hot and hot-humid conditions. This investigation assessed, both independently and in combination, the effects of heat exposure (95^{o}F, 60%RH) and US Army standard dosages of nerve agent antidotes (2 mg atropine and 600 mg 2-PAM chloride) on the performance of a variety of tasks selected for their relevance to military operations. Sensory, sensory-motor, and perceptual-cognitive functioning, subjective reactions, and direct military skills such as M-16 rifle marksmanship were assessed. Two identical studies were conducted, with and without the subjects wearing chemical protective clothing. In each study, soldier volunteers were first trained to asymptotic performance on the tasks, and then, over a period of four test days, completed a counterbalanced sc..edule of the drug/no drug and heat/no heat conditions while outfitted in either the Battle Dress Uniform (BDU) or the MOPP-IV chemical protective ensemble. Three 2-hour test cycles were conducted on each test-day. In BDUs, compared to the placebo condition a single dose of nerve agent

HEALTH AND PERFORMANCE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

antidote significantly impaired visual reaction time (5% slower for simple, and 11% slower for choice), gross body mobility (12% poorer), rifle marksmanship (3% less accurate), and verbal reasoning (6% slower). Compared to a 70°F control condition, 95°F ambient heat significantly impaired arm-hand steadiness (10% poorer), and rifle marksmanship (13% poorer). However, dexterity improved by 2 to 8 percent. Nerve agent antidote and ambient heat did not interact to further impair soldier performance. In MOPP-IV, the soldiers experienced more bodily discomfort and negative moods than when dressed in BDUs. None of the soldiers could complete the 95°F test sessions when dressed in MOPP-IV. Compared to the placebo condition, a single dose of nerve agent antidote significantly impaired reaction time (27% slower for simple, and 50% slower for choice), gross body mobility (12% less mobile), and rifle marksmanship (10% to 12% less accurate). In addition, two measures of cognitive activity were slowed (verbal reasoning by 14% and digit symbol substitution by 17%). Visual acuity, phoria (ocular muscle balance), and stereopsis (fine depth perception) were all significantly impaired by heat, drug, and the effects of continued exposure to the stress conditions. Visual contrast sensitivity was mainly affected by heat and continued exposure. The influence of heat alone was dramatic under MOPP-IV, in that all tests showed significant impairments under the 95°F conditions. This was attributed to the greatly increased heat load generated by wearing the impermeab. . MOPP-IV system. An analysis of only the data for Cycle 1 in MOPP-IV also showed impairment of some tasks (visual acuity, reaction time, tremor, verbal reasoning), but these impairments were less extensive and were primarily due to drug effects. A separate analysis of overall endurance times of the soldiers showed that half of the subjects voluntarily withdrew, while the other half were removed by the medical monitor. Also, the group mean endurance time in the heat while wearing MOPP-IV was significantly shorter under drug than under placebo. The findings of this study clearly show that although atropine/2-PAM produces significant impairment of some primarily visual performance tasks, severe heat exposure can impair a wide range of militarily-relevant psychologically based tasks. Heat stress resulting from wearing

HEALTH AND PERFORMANCE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

MOPP-IV at high temperature levels not only potentiates the effects of atropine/2-PAM, but also can incapacitate personnel within two hours of exposure. Furthermore, a wide range of psychological tasks are significantly impaired during the two-hour period prior to incapacitation. (Publications: 9, 10, 11, 12, 13; Abstracts: 24; Presentations: 30, 31)

4. Data collection has been completed in a collaborative study with Wellesley (MA) College. The study was designed to follow up results (unpublished) previously obtained in-house with female soldiers which showed highly significant relationships between oral contraceptive (OC) use and complex perceptual-motor performance. Information about personal demographics, personality, attitudes, and use of OCs and beverages containing caffeine, alcohol and aspartame were obtained from 65 female college students. From this group, 20 OC users and 23 non-users were tested, individually, three times during their menstrual cycles for reaction time, steadiness, perceptual-motor coordination, color discrimination and immediate and delayed recall. Excessive within subjects variability in length of menstrual cycle precluded determining cycle phase differences in performance between users and non-users of OCs. However, many complex and heretofore unknown relationships have been found based on over-all comparisons of users and non-users. Among preliminary findings are: (a) Among "heavy" users of caffeine, there was a linear decrease in steadiness from non-users of OCs through short-term users to long-term users; (b) Users of OCs who also drank caffeinated beverages tended to have poorer color discrimination; (c) Among "neurotics," users of OCs had slower reaction times; (d) A complex interaction was found between OC and diet coke use and delayed recall. Best performers did not use OCs or diet coke. Users of diet coke without OCs or of OCs without diet coke had the poorest delayed recall. Users of both OCs and diet coke did not have the poorer recall associated with the use of either separately; (e) Length of time on OCs was a significant variable, even in this young population, and was related to introversion and neuroticism; (f) A significant

HEALTH AND PERFORMANCE DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

interaction was found between OC use, extraversion and reported number of automobile accidents.

5. Seventeen male soldiers who consumed a calorie-deficient (CD) ration and 17 who consumed a calorie-adequate (CA) control ration were studied for 30 days during a U.S. Army Special Forces training exercise. Mean daily energy intake was 1950 kcal for the CD group and 2800 kcal for the CA group. Blood was sampled and psychomotor performance assessed at the start and completion of the study. Previously we noted that plasma levels of the neurotransmitter precursors tryptophan and tyrosine decreased significantly in the CD but not the CA group (FASEB J. 3(3):A463, 1989). To determine whether altered precursor availability was related to changes in mental performance over the course of the study, linear regression was employed, with changes in amino acid ratios (tryptophan or tyrosine over the sum of the other large neutral amino acids) as predictor variables and behavioral changes as dependent measures. Decrements in tryptophan ratio were associated with impairments of simple visual reaction time ($p=0.009$) and choice visual reaction time ($p=0.018$). Decreased availability of tryptophan to the brain reduces synthesis of serotonin and may account for some of the adverse behavioral changes associated with undernutrition. (Abstracts: 25)

6. A manuscript, which was accepted for publication in Aviation, Space, and Environmental Medicine, detailed the corrected computational procedures for the alertness factor of the Environmental Symptoms Questionnaire (ESQ), which were found to be invalid as reported in the original manuscript. Therefore, this paper computed the correct procedures and their rationale. The new computational procedures for the alertness factor are conceptually correct and provide a valid indicator of the subjective state of alertness. The ESQ is a critical technique to assess subjective states associated with soldier tolerance to extreme environments. (Publications: 19)

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

7. A manuscript, which was accepted for publication in Aviation, Space, and Environmental Medicine, assessed altitude symptomatology and mood states during a climb to 3,630 meters. Self-rated symptoms and moods were evaluated five times in seven male soldiers during a climb of Mount Sanford, Alaska. Seven symptom factors and two mood factors were found to be adversely affected over time by the changes in altitude. These changes occurred primarily at 3,630 meters and most also occurred at 3,080 meters. This study further validates the extent of symptomatology and mood changes associated with military field exposures to high terrestrial elevations with laboratory data bases. (Publications: 20)

8. Personnel from Health and Performance Division collected symptom, mood, and cognitive performance data during three operational field tests: (a) Battalion Aid Station Test at the Human Engineering Laboratories in June; (b) Chemical Reconnaissance Squad Operations Test at Fort Knox in August; (c) Tank Combat Service Support and Mobility Test at Fort Knox in October and November. Military personnel performed varied military duties in MOPP-IV during each test. Personnel in the Battalion Aid Station Test triaged, treated, and prepared mock chemical casualties (manikins) for evacuation. Chemical Reconnaissance Squad Operations personnel determined the type and extent of chemical agents in a contaminated area. They also evaluated suspected contaminated areas and verified that terrain areas of special tactical importance were free of contamination. Personnel participating in the Tank Combat Service Support and Mobility Test repaired broken tank tracks, refueled tanks, and performed a variety of maintenance tasks in daylight and night conditions. Symptom, mood, and performance data showed great variability, reflecting perhaps soldier differences and the influence of many uncontrolled variables. Patterns in such measures were significantly different in soldiers who terminated a daily operational test session than soldiers who completed it. These studies also provided dramatic demonstrations of the impact of some known variables upon the soldier's ability to function in MOPP-IV. Such factors included: behavioral strategies, work-rest cycles,

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task rotation, adequate water intake, minimizing solar loading (before work is begun or when resting), and moderate evening activities during rest and relaxation periods. (Key Briefings: 40)

9. To date, all sanctioned development and testing of the performance assessment battery sponsored by the Office of Management of Performance Assessment Technology (OMPAT) has been with full-sized desktop personal computers and colored displays. Recent advances in electronic, computer, and display technology permit storage and execution of large software programs on laptop computers; their high resolution displays now rival many of the qualities of desktop displays. This year, coordination with OMPAT personnel resulted in the creation of a collaborative project with personnel from the Department of Behavioral Biology at WRAIR to transfer OMPAT measurement methodologies and software to a high performance lap-top computer. Subsequently, these methodologies will be validated on both portable and desktop computer systems, possibly using exposure to simulated high altitude as a challenge stressor. Software modifications and revisions will be obtained by contract.

10. When people travel to terrestrial altitudes greater than 3000 m, their physiological and psychological well-being, mental processes, senses, sleep, and physical work capacity are impaired to some extent. Within 4-12 hours, acute mountain sickness and its discomforts usually result. Fortunately, normal compensatory processes, given sufficient time, reduce many adverse effects caused by moderate exposure to high altitude. Two USARIEM researchers authored a book chapter this past year which describes these physiological and psychological limitations associated with exposure to high altitude and strategies used to decrease them. The chapter will be published in 1990 by J. Wiley and Son in the Handbook of Military Psychology (Vol. 1). (Publications: 1)

11. Twenty subjects were tested in a repeated-measures, experimental study to determine if tyrosine, a substance found in

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animal protein foods, reduces the effects of environmental stressors. Tyrosine (85 or 170 mg/kg) or placebo was administered double-blind in a counterbalanced order during three stressful environmental exposures. A control environmental condition with placebo was also studied. Subjects were evaluated with a variety of symptom, mood, and cognitive performance measures and plasma levels of tyrosine were also assayed. Our results indicated that tyrosine reduces symptoms, adverse moods, and performance impairments in subjects most affected by the environmental stressors. Both doses of tyrosine reduced such adverse effects; however, the two doses did not differ. These findings are in close agreement with an earlier USARIEM study. (Publications: 2; Presentations: 27)

12. In spite of present knowledge that central nervous system function depends upon chemical neurotransmission, there is no technology available to directly monitor in vivo brain chemistry. Our laboratory has developed a procedure which involves the acute implantation of a microdialysis probe into the rat brain, continuous micro perfusion of a physiological or pharmacological solution, and collection of dialysates. Analysis of the dialysates are performed on high pressure liquid chromatography with electrochemical detection.

13. A brain microdialysis study was conducted to determine the neuromodulatory effects of cyclo(His-Pro) on the dopaminergic system in the striatum of the rat brain. Histidyl-proline-diketopiperazine (CHP) is a biologically active peptide related to TRH, ubiquitously distributed in the brain. CHP administration has been reported to decrease striatal dopamine (DA) in brain homogenates and inhibit tyrosine hydroxilation (TH) in-vivo. However, CHP has also been reported to augment stereotypic behavior induced by d-amphetamine, possibly by increasing the release of DA. In the present microdialysis study, extracellular levels of DA and its metabolites (DOPAC and HVA) were monitored in the striatum of rats to reconcile these conflicting reports and study the dopaminergic mechanism of CHP action. Pretreatment with CHP (0.5

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mg/kg, s.c.) (n=5), or the equivalent volume of saline in a control group (n=5), was followed 30-min by 5 mg/kg of d-amphetamine (i.p.). Dialysate samples were collected and analyzed by HPLC-EC. Statistical analysis (ANOVA) of the results revealed a significant difference between the two pretreatments ($p < .05$) for DA levels post d-amphetamine, but not for DOPAC or HVA. No difference was found between baseline DA values. No synergistic effect of CHP was observed on extracellular DA induced by d-amphetamine. On the contrary, following the initial response to amphetamine, striatal DA in CHP treated rats was significantly lower than in saline treated animals across time. Since there were no variations in DOPAC or HVA between the two groups across time, it is unlikely that CHP interferes with d-amphetamine induced inhibition of DA reuptake. Our data and previous findings suggest that CHP might have two opposing effects on DA activity. Attenuation of the dopaminergic response to d-amphetamine might be best explained on the basis of striatal DA depletion, possibly via TH inhibition. Therefore, it may be possible for CHP to attenuate the adverse dopaminergic responses of amphetamine administration (such as increased motor responses, addictive properties, and psychotic behavior) without compromising the noradrenergic response of increased vigiliance.

14. Procedures for measurement of two types of evoked potential protocols, the Brainstem Reliability Evoked Potential, (BAEP), and the Pattern Reversal Evoked Potential, (PREP) were validated in the USARIEM evoked potential laboratory. Laboratory norms were established for each of these protocols. A total of 35 subjects were used for this initial database. Both types of evoked potential protocols proved to be consistent and stable measures for their assessment of their respective examinations of central nervous system functioning. This critical technology enables the systematic correlation of changes in the performance of cognitive and sensory motor tasks to changes in the amplitude and latency of neuronal signals in specific pathways within the brain. Such performance assessment technology represents the only window to the human central nervous system to elucidate mechanisms involved with

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the performance of military skills. (Publications: 15; Key Briefings: 39, 42)

15. A study was conducted at altitude to examine the effects of altitude exposure, fatigue from a forced march at altitude and the effect of a supplemented carbohydrate diet on marksmanship performance. Sixteen experienced male marksman fired an M16 rifle equipped with a Noptel ST1000 laser system from a standing unsupported position at a 2.3 cm diameter circular target from a distance of 5 m. Subjects were tested at rest and after a maximal 20.4 km run/walk ascent from 1830 m to 4300 m following acute and chronic exposures to altitude. Sighting time (the interval between signal light presentation and firing) and accuracy (distance of shot impact from target center) were measured. Fatigue and time at altitude had independent effects on marksmanship. Sighting time was unaffected by fatigue. Accuracy was reduced 10.5% by fatigue but improved 15.5% following chronic altitude exposure. Diet did not affect marksmanship performance. Therefore, acclimitization to altitude attenuated the initial impairment in marksmanship found with the acute exposure.

16. A study was conducted to examine the effects of three carbohydrate diets and the effect of a forced load carriage march on marksmanship performance. Eight experienced male marksman fired an M16 rifle equipped with a Noptel ST1000 laser system from a standing unsupported position at a 2.3 cm diameter target from a distance of 5 m. Subjects carried a 45 kg load during a forced march at 3.5 mph. Marksmanship testing was done pre and post exercise. Preliminary results reveal accuracy was unaffected by diet or exercise. However, sighting time showed a significant increase post exercise for the low carbohydrate diet. (Key Briefings: 41)

17. A study was conducted to examine the effects of body weight loss (BWL) and rehydration on marksmanship performance after exercising in the heat in MOPP IV. Sixteen male soldiers walked (2.5 mph) for six 50/10 minute work/rest cycles. Water intake was

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ad lib. Subjects were tested on the Weaponeer M16A1 rifle simulator in NO MOPP and MOPP IV pre and postexercise. Two post hoc groups were formed for % BWL/hr and % rehydration using the median as the cutoff point. The results of this study show that marksmanship accuracy is compromised after exercising in the heat in MOPP IV. Furthermore, individuals with a high %BWL/hr performed significantly poorer in marksmanship compared to individuals with low %BWL/hr. (Publications: 14, 22; Presentations: 34, 41)

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ABSTRACTS:

24. Kobrick, J.L., R.F. Johnson and D.J. McMenemy. Effects of heat and atropine/2-pam chloride on performance in chemical protective clothing. Proc. of the First Convention of the American Psychological Society. 28, 1989.

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27. Banderet, L.E. and H.R. Lieberman. Treatment with Tyrosine, a neurotransmitter precursor, reduces environmental stress in humans. Proc. 4th Conference Federally Supported Human Nutrition Research Units and Centers. Bethesda, MD, February 1989.

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PRESENTATIONS:

31. Kobrick, J.L., R.F. Johnson and D.J. McMenemy. Nerve agent antidotes and heat exposure: Effects on task performance while wearing BDU and MOPP-IV clothing systems. Medical Defense Bioscience Review, Baltimore, MD, August 1989.

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33. Tharion, W.J. Boosting endurance and performance. First Annual Conference on Sport Psychology for Coaches. Miami, FL, June 1989.

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KEY BRIEFINGS:

35. Richard F. Johnson, Ph.D. Treatment drugs and sentry duty: Effects on target detection and rifle marksmanship; Review and Analysis for the Medical Chemical Defense Research Program, USARIEM, Natick, MA, 1989.

36. Richard F. Johnson, Ph.D. Antihistamines, sentry duty, and rifle marksmanship; Joint Working Group on Drug Dependent Decrements to Military Performance 3rd quarterly meeting, Dayton, OH, 1989.

37. Richard F. Johnson, Ph.D. Chemical protection and environmental stress: Effects on rifle marksmanship and psychomotor performance; Current Concepts in Environmental Medicine Course, USARIEM, Natick, MA, 1989.

38. Harris R. Lieberman, Ph.D. Strategies to sustain performance during adverse operational scenarios; 9th Special Forces Medics, USARIEM, Natick, MA, 1989.

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KEY BRIEFINGS:

39. Donna J. McMenemy, B.S. Current progress in drug dependent degradation research within USARIEM's Health and Performance Division; Joint Working Group on Drug Dependent Degradation on Military Performance, San Diego, CA, 1989.

40. William J. Tharion, M.S. USARIEM's (Health and Performance Division) update and proposed involvement in FY 89-90 for P^2NBC^2; TSAG and $JWGP^2$ Meeting, U.S. Army Chemical School, Ft. McClellan, Anniston, AL, May, 1989.

41. William J. Tharion, M.S. Field marksmanship studies using the NOPTEL ST-1000; Colonel McCarty, Deputy Commander of MRDC, USARIEM, Natick, MA, May, 1989.

42. William J. Tharion, M.S. USARIEM's progress update for 89 research plans; Third Quarterly FY89 $JWGD^3$ MILPERF Meeting, Dayton, OH, 1989.

SIGNIFICANT VISITORS:

Major Darcelle Delrie, Flight Surgeon, USAARL, Fort Rucker, Alabama.

Dr. Robert L. Stephens, Research Psychologist, USAARL, Fort Rucker, Alabama.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Bernard J. Fine, Ph.D. Fellow, American Psychological Society.

Richard F. Johnson, Ph.D. Senior Lecturer in Psychology, Northeastern University, Boston, MA.

Richard F. Johnson, Ph.D. Reviewer, Psychosomatic Medicine.

Richard F. Johnson, Ph.D. Elected Fellow, American Psychological Society.

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PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Richard F. Johnson, Ph.D. Program Chairman, Natick Chapter of the Sigma Xi, The Scientific Research Society.

Terry M. Rauch, Ph.D. Special Service Appointment, Doctoral Dissertation Committee, Psychology Department, Graduate School, Boston University.

Terry M. Rauch, Ph.D. Reviewer, Military Psychology.

William J. Tharion, M.S. Invited speaker at The Sport Psychology Institute First Annual Conference.

William J. Tharion, M.S. Member of New England American College of Sports Medicine and American Alliance for Health, Physical Education, Recreation and Dance.

HEAT RESEARCH DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. To assess the effects of potassium deficiency on thermal tolerance, 3 groups (n = 12g) of rats (475 g) were fed a nutritionally complete (C), potassium-deficient (-K), or potassium-supplemented (+K) diet for 14d, followed by passive exposure (unrestrained) to heat stress (41.5°C) until core temperature reached 42.5 - 42.6°C. Circulating K^+ levels were significantly p<0.01) reduced in the -K group before and after exposure to the severe heat stress, while plasma sodium levels were unaffected by dietary manipulation. Mean thermal tolerance was 178 min for the C and 149 min for the +K groups (p = ns), but was significantly (p<0.0.) reduced in the -K group (86 min). While the total mean water losses were significantly (p<0.01) different among groups (C = 35.6, +K = 25.1, -K = 15 g), rates of water loss were similar (.20, .18, .17 g/min, respectively). Despite the similar rates of water loss, rates of heat gain were significantly different among the 3 groups (.024, .032, .55°C/min, p<0.01). Clinical chemical indices of heat injury were generally similar among groups. However, following exposure to the severe heat stress, while circulating glucose levels were reduced in both the C (177.4 pre, - 163.1 mg/dl post) and +K (176.9 - 144.7 mg/dl) groups, plasma glucose levels were significantly (p<0.01) increased in the -K group (176.6 - 214.9 mg/dl). Lactate levels were also most markedly increased in the -K group following heat exposure. These results suggest that factors other than evaporative heat loss, perhaps increases in glucose metabolism and metabolic heat production, may be contributing to the significantly decreased thermal tolerance in this group. Moreover the results clearly demonstrate the importance of maintaining circulating electrolyte levels in reducing the risk of heat injury in this animal model. (Publications: 10, 16)

2. An orthostatic tolerance test (OTT) was administered to 18 unacclimated soldiers (28±1yrs) before and after 4.5 h of intermittent exercise (50 min/h) in a hot environment (33°C) while fully encapsulated in chemical protective clothing and

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hooded mask. Blood pressure (BP) and heart rate (HR) were measured 2 and 4 min after each soldier assumed an upright position from recumbency. Pre-exercise, all subjects completed OTT with responses typical of euhydration: HR and diastolic pressure (P_D) rose slightly, while systolic (P_S) and mean BP changed minimally. Post-exercise, 13 subjects completed OTT (tilt tolerant) and 5 subjects (tilt intolerant) prematurely terminated OTT with pre-syncopal signs. During post-exercise OTT, HR increased (intolerant, 32$\pm$4 bpm vs tolerant, 23$\pm$ bpm) and P_S decreased (intolerant, -30$\pm$9 mmHg vs tolerant, -16$\pm$3 mmHg; p<.06) in both groups. P_D fell in the tilt intolerant (2$\pm$7 mmHg) but rose in the tilt tolerant soldiers (12$\pm$ mmHg, p<.04) eliciting a decrement in BP in intolerant soldiers (-12$\pm$3 mmHg) compared to the tolerant subjects (3$\pm$2 mmHg, p<(.03). Dehydration rates (0.32 kg/h) and final core (38.7°C) and skin (36.6°C) temperatures were similar and did not discriminate between tilt intolerant and tolerant soldiers. Following rehydration and recumbency in a cool (21°C) room, presyncopal symptoms lessened and OTT responses improved in four of the tilt intolerant soldiers suggesting that compensatory mechanisms during work in the heat were less effective in these subjects. The results of this study may have significant value for determining soldier susceptibility to syncope during hot weather operations, and for treating syncopal episodes. (Publications: 23; Abstracts: 37; Briefings: 50)

3. This study was designed to evaluate the effects of a modified through-mask drinking system (MDS) on voluntary fluid consumption. Eighteen male soldiers walked on a treadmill (4.02 km/hr, 50 min/hr for 6 hr) in a climatic chamber (32.6°C). Subjects wore chemical protective gear (trousers, jacket, boots, gloves, and M17A1 hooded protective mask) and were randomly assigned one of two through-mask drinking system: CS (n=q), the current gravity fed system or MDS (n=9), a prototype hand-pump drinking system. Because decontamination of the mask and drinking connections was performed prior to drinking, the overall

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use of the CS was rated significantly more difficult during both work and rest than the MDS. Failure to decontaminate connections prior to drinking was noted early in the trial in 2 soldiers using the CS suggesting a greater risk of accidental contamination associated with this system. Drinking with the MDS had no measurable adverse affect on hydration status of the test subjects. The significantly greater frequency of drinking (3 drinks/walk, MDS vs 1 drink/walk, CS) and the trend toward higher intake rates during the walks with the MD (0.35 L/hr vs 0.24 L/hr, CS) indicates the potential advantage of this system during operations werein periods of inactivity are usually limited. Heat strain experienced by soldiers drinking with the MDS was significantly less than that with the CS, and the greater heat stored in CS may have been due to the additional work and frustration associated with using this system. Minor effects on performance were observed; exercise times were not different between CS and MDS. The significantly greater dispersion in the vertical shot group measure of marksmanship by MDS may have been related to their reportedly greater level of fatigue. We have concluded from these data that the prototype MDS did not compromise fluid intake during the experimental scenario, and should be more effective and efficient than the CS in maintaining hydration status in soldiers donned in MOPP IV, especially during periods of work. (Publications: 15, 22, 23, 24, 25, 26, 27; Abstracts: 36, 37; Presentations: 45; Briefings: 51, 52, 53, 54, 55, 56, 57)

4. Because nerve agents have toxic central as well as peripheral effects, a desirable prophylaxis would also have central as well as peripheral sites of action. The carbamate physostigmine (PH, both central and peripheral sites of action) has been under consideration. The administration of PH to rats (500g) exercising on a treadmill (26°C, 50% rh, 11 m/min, 6° incline) resulted in a dose response decrement in endurance, decreased running time to exhaustion), and a dose response increase in heating rate (rate of of rise of core temperature). Having

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characterized these dose response decrements at 40, 50, and 60% cholinesterase inhibition, we used this model to examine the efficacy of the following 4 anticholinergic drugs as adjuncts to PH administration: atropine (AT), scopolamine (S), aprophen (AP), and trihexyphenidyl (THP). Each of these drugs was administered (iv) in varying doses just prior to the administration of 200 ug/kg of PH (60% inhibition) prior to running the rats to exhaustion. An optimum dose was determined for each of the drugs as follows: AT- 200 ug/kg, S- 8- 16 ug/kg, AP- 3000 ug/kg, and THP- 800 ug/kg. The administration of 200 ug/kg of PH alone resulted in a run time and heating rate that were 53 and 186% respectively of control values. The optimum doses of each adjunct when administered with PH resulted in run times and heating rates (expressed as % of saline control values) as follows: AT- 70, 157 %; S- 79, 135%; AP- 80, 111%; and THP- 77, 123%. The administration of any one of these 4 adjuncts resulted in a significant improvement in endurance and heating rate over the administration of PH alone. (Publications: 11, 18, 19, 20; Abstracts: 34, 35; Presentations: 41, 46, 47; Briefings: 52)

5. The diuretic furosemide was used in combination with dietary sodium (Na) restriction to quantify the effects of moderate to severe Na depletion on heat tolerance in a validated model of heat stress in rats. Rats were divided into four groups as follows: a control group (I) had a normal diet and tap water; group II normal diet and tap water plus the diuretic furosemide at a dose of 10 mg/kg/day, ip; group III had a Na-free diet and deionized drinking water; group IV, Na-free diet and electrolyte-free water plus furosemide. Both the dietary and drug manipulations affected significant ($p<.05$) negative electrolyte and water balances. Group IV consistently exhibited the greatest decrements. Following the 4d depletion all four groups were acutely exposed to a 42°C, 25-30% rh environmental heat stress during which time core body temperature increased. The time required for rectal temperature to reach 42.6°C was significantly ($p<.05$) decreased from a time of 242$\pm$ min in the control group to

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176±14, 181±8 and 111 ± 11 min in groups II, III and IV, respectively. It is concluded that Na deprivation and diuretic treatment can elicit a 25-50% reduction in heat tolerance due to electrolyte depletion and dehydration. These data suggests that during environmental heat stress uncompensated negative Na balance may predispose an individual to heat illnesses. (Publications: 3, 5; Presentations: 38, 39, 42; Briefings: 50, 51, 52, 53, 54)

6. We have employed the primed constant infusion technique to investigate the metabolic effects of the organophosphate antidote, atropine, on glucose homeostasis in rats. Our data indicate that glucose production significantly ($p<.05$) increased (24.0±2.0 vs 30.9±2.6 umoles/kg.min) following atropine administration. The elevated rate of glucose turnover was associated with concomitant increases in glucose oxidation (8.3±.6 vs 12.0±.8 umoles/kg.min), the % of glucose uptake oxidized (37.2±2.0 vs 44.6±2.6), and the % carbon dioxide produced from glucose (8.4±.7 vs 12.0±1.8). Presumably, these glucokinetic changes were mediated by elevated plasma catecholamines (Epi: 166±19 vs 271±50 pg/ml; Norepi: 262±24 vs 525±63 pg/ml, $p<0.05$) since other glucoregulatory hormones (insulin, glucagon, and corticosterone) were not significantly affected by atropine administration. In addition, there was no change in VO_2 associated with atropine administration. Since these data indicate that atropine enhances glucose production and utilization, further studies may be designed to assess the effects of atropine in humans during varying environmental conditions of energy requirements. (Publications: 8)

7. Final report, FORTRAN source code, and documentation needed to process and display satellite-derived WBGT index images have been received through SBIR contract No. DAMD17-86-C-6004. Software employs data obtained from the Advanced Very High Resolution Radiometer (AVHRR) and TIROS Operational Vertical Sounder (TOVS) instruments aboard the NOAA polar orbiting weather

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satellites. The average difference between satellite-derived and surface level WBGT index measurements was found to be -0.78°C (bias low) and the Root Mean Square Error was 1.83°C at the 1.1 x 1.1 km target pixel for 11 satellite passes at Fort Hood, Texas in June 1988. A climatologically based WBGT heat stress atlas, suitable for pre-deployment planning was produced. A satellite-derived heat stress image data base consisting of 24 passes over Southwest Asia in mid-summer 1988 and 1989 was delivered. (Publications: 21)

A "straw man" military specification and conceptual drawings for an improved Army environmental heat stress monitor have been developed. This electronic device will measure prevailing local heat stress levels and automatically display recommended drinking water needs, and work/rest cycle limits based on user specified clothing and work rate. The device is rugged, lightweight (less than 14 oz) compact (fits in BDU pocket), easy to use (4 function keys), and completely self contained. This product would provide a stand-alone capability for heat injury prevention at the battalion/company level.

8. The risk of returning recovering heatstroke casualties to normal duty in a hot environment cannot be objectively determined. This research was designed to determine, by case histories, whether (a) certain individuals could remain heat intolerant for extended periods beyond clinical recovery from exertional heatstroke; (b) these same individuals could recover a "normal" state of heat acclimation, thereby ruling out a genetic predisposition to heat injury; and (c) diagnostic tests of physiological status could provide guidelines for therapeutic recovery. We recognized that this information could be used to assess our current strategies for enhancing recovery, develop new physical training or heat acclimation programs if necessary, and provide objective data for accurate analysis of reinjury rates and risk. Also, data on the time course of recovery, assessed by clinical diagnostic tests of recovery and residual heat

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

intolerance could assist U.S Army commanders, training instructors and medical officers to determine the world-wide deployability of previously heat-injured soldiers. Ten prior exertional heatstroke patients (4 officers, 6 enlisted, all males) were declared "clinically normal" by their physicians. They arrived at this laboratory (61$\pm$7 days after heatstroke) for a 12-day evaluation, including seven days of heat acclimation (40.1°C, 90min/day) and two 6-hour heat tolerance tests. Our tests identified: nine individuals (90 %) who were fully recovered during their initial attempt at heat acclimation; one individual (10 %) who did not achieve normal heat acclimation responses until 11.5 months post-heatstroke (3 visits); and three individuals (30 %) who demonstrated marked exercise-induced elevations in the serum enzyme CPK, suggesting either marked detraining during recovery or a susceptibility to muscle injury. Our results suggest that: (a) no patients were hereditarily heat intolerant prior to heatstroke, based on "normal" heat acclimation responses; (b) none of the factors measured in the hospital or laboratory was clearly related to recovery from exertional heatstroke; (c) the current recommendation to restrict all physical activity during recovery can be counter-productive; (d) patients can benefit from carefully designed physical training and heat acclimation programs which include on-site medical monitoring and gradual increments in the duration/ frequency/intensity of heat exposure and exercise. (Publications: 4, 5, 6, 13, 17; Abstracts: 28, 29; Presentations: 40; Briefings: 49, 50, 51, 52)

9. This study evaluated body composition and physiologic measurements as predictors of exercise heat tolerance (EHT) differences and exercise time (T), in 18 unacclimatized males attempting 6 periods of treadmill exercise (50min walk/h, 4km/h, 0% grade) in MOPP IV in the heat (33°Cdb, 20%rh). Subjects (n=6) completing 6 periods of exercise (300 min) were defined high-EHT (H); and those who were removed prematurely (n=12, x$\pm$SE: 193$\pm$10min) were defined low-EHT (L). Significant (p<.05)

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

differences (H vs L) were observed at hour 3 (the final period completed by all subjects) in: mass-to-surface area ratio (37.9 vs 40.4kg/m^2), percent body fat (13.9 vs 19.0%), heart rate (HR) (133 vs 157beats/min), mean skin temperature (35.6 vs 36.6°C), heat storage(34.3 vs 49.9Kcal/m^2/3h). No pretrial differences were observed in age, height, surface area, physical training; or at hour 3 in rectal temperature, sweat rate, ad lib water intake. Multiple linear regression analysis identified HR as the only significant predictor of T (r^2=.58, p<.001). These data emphasize the importance of cardiovascular factors (e.g. HR) in the prediction of T, and may be useful in identifying individuals with reduced EHT or an increased risk of heat illness, when exercising in garments that reduce heat dissipation. (Publications: 25)

10. The physiologic responses to an intense heat acclimation (HA) regimen (treadmill, 41.2°C, 8 days, 56 min exercise/44min rest) and the effects on stress and fluid balance hormone responses were examined in 13 unacclimated male volunteers. Venous blood samples were collected before (PRE) and after (POST) exercise (days 1, 4, 8) and analyzed for plasma renin activity (PRA), aldosterone (ALD), cortisol (PC), plasma volume shifts (ΔPV%), sodium concentration (NA^+), and potassium concentration (K^+). HA response (day 1 vs day 8) indicated reduced strain (P<0.05): decreased heart rate, rectal temperature, skin temperature, improved defense of PV, and attenuated PC responses. While plasma Na^+ demonstrated no change during daily exercise, K^+ (P<0.01), PC, PRA, and ALD increased (P<0.05) more than ΔPV% (day 1:-7.1%, day 8:-5.1%) accounted for. NA^+ and K^+ did not change as a result of HA, and there was no change in fluid balance hormones (e.g., PRA, ALD). It was concluded that this intense heat acclimation regimen reduced physiologic strain by mechanisms other than alterations in fluid balance hormones and offered few physiologic advantages which cannot be gained through conventional heat acclimation techniques (e.g., walking). (Publications: 12; Briefings: 49, 50, 51, 52)

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

11. Within the context of a clinical symposium (Exertional Heatstroke: An international perspective) organized and chaired by the staff of the Heat Research Division, six papers were presented (three from this Institute) organized to focus scientific interest and debate on the following areas of exertional heatstroke: exercise as a causative factor, physiological systems involved, symptoms and diagnosis, differentiating between heatstroke and heat exhaustion, treatment and management of heatstroke in the field, whole body cooling techniques, changes in symptoms during evacuation and hospitilization, a new theory deliniating the biochemical mechanisms involved in cell injury, physiological and pathological factors underlying heat intolerance, congenital and acquired heat intolerance, time course and extent of recovery in patients, and ability of recovering patients to acclimate to exercise heat exposure. (Publications: 1, 2, 3, 4, 5, 6, 13, 15, 16; Abstracts: 29, 30; Presentations: 40, 43, 44, 45, 46)

12. The question of how heat stress is translated into heat strain at the cellular level and how this accounts for the pathological findings of generalized tissue injury was the topic of intensive review. The intent was not to downplay the seriousness of the systemic condition in heatstroke but to focus attention and interest on the impact of heat on the cell as a model for other factors (shivering, carbamate stimulation, cold, hormones, neural and toxic agents) which alter membrane integrity and permeability. The dynamic equilibrium between the inherent leakiness and the tendency of cells to swell versus the constant application of cellular sources of energy to osmotic pumps was the underlying theme. The reversible and non-reversible stages in cellular injury were examined from the perspectives of tissue perfusion, oxygen availability, energy availability versus energy demand, and the structural-functional correlates. The similarity between muscle fatigue, energy depletion, and the biochemical basis for rigor and the pathological picture of heatstroke were examined. The often overlooked reciprocal

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SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

relationship between heating rate (accumulation of stored heat) and total work output was linked to direct stimulation of anaerobic-glycolytic energy sources used to power membrane-bound osmotic pumps (Na-K ATPase). New evidence suggesting that lowered serum potassium could inhibit sodium pump activity was used to develop a new biochemical basis for asserting a new role of hypokalemia in the etiology of heatstroke. This exciting new insight leads to a concept predicting the turning-on of energy wasting futile cycles within skeletal muscle and serves to explain prior published work from this laboratory documenting reduced work output and increased heat production in animal models of potassium depletion and heatstroke. (Publications: 13, 14, 15, 16; Abstracts: 29, 32, 33; Presentations: 43, 44, 45, 46)

PUBLICATIONS:

1. Armstrong, L.E. Considerations for replacement beverages: fluid-electrolyte balance and heat illness. Proceedings of a Workshop of the use of Carbohydrate - Electrolyte Solutions. National Research Council, Food and Nutrition Board, Washington, DC. (In Press).

2. Armstrong, L.E., and R. W. Hubbard. Application of a model of exertional heatstroke pathophysiology to cocaine intoxication. J. Emerg. Med. (In Press).

3. Armstrong. L.E. Hypohydration. NSCA J. 11:68-69, 1989.

4. Armstrong, L.E., R.W. Hubbard, E.L. Christenson, and J.P. DeLuca. Evaluation of a temperate environment test of heat tolerance in prior heatstroke patients and controls. Eur. J. Appl. Physiol. (In Press).

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PUBLICATIONS:

5. Armstrong, L.E., J.P. DeLuca, R.W. Hubbard, and E.L. Christensen. Exertional heatstroke in soldiers: An analysis of predisposing factors, recovery rates, and residual heat intolerance. USARIEM Technical Report No. T/5-90, 1989.

6. Armstrong, L.E., J.P. DeLuca, R.W. Hubbard. Time course of recovery and heat acclimation ability of prior exertional heatstroke patients. Med. Sci. Sports Exercise. 22:36-48, 1990.

7. Durkot, M.J., and R.R. Wolfe. Invasive sepsis: Hypo verses hypermetabolic model. J. Surgical Res. (In Press)

8. Durkot, M.J., O. Martinez, V. Pease, R.P. Francesconi, and R.W. Hubbard. Atropine: Effects on glucose metabolism. Aviat. Space Environ. Med. (In Press)

9. Francesconi, R.P., M.N. Sawka, R.W. Hubbard, and K.B. Pandolf. Hormonal regulation of fluid and electrolytes: Effects of heat exposure and exercise in the heat. In: J.R. Claybaugh and C.N. Wade (eds) Hormonal Regulation of Fluid and Electrolytes: Environmental Effects. Plenum Publishing Corp., New York, 1989, pp. 45-85.

10. Francesconi, R.P., M. Bosselaers, C.B. Matthew, and R.W. Hubbard. Plasma volume expansion in rats: Effects on thermoregulation and exercise. J. Appl. Physiol. 66:1749-1755, 1989.

11. Francesconi, R.P., C.B. Matthew, R. Anderson, N. Leva, L. Gowenlock, and R.W. Hubbard. Aprophren and scopolamine: Metabolic and clinical chemical effects during exercise. Proceedings of the 1989 Medical Defense Bioscience Review. 1:545-548, 1989.

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PUBLICATIONS:

12. Francesconi, R.P., P.C. Szlyk, I.V. Sils, N. Leva, and R.W. Hubbard. Plasma renin activity and aldosterone: Correlations with moderate hypohydration. Aviat. Space Environ. Med. 60:1172-7, 1989.

13. Hubbard, R.W. and L.E. Armstrong, Chairpersons. Clinical Symposium: Exertional Heatstroke: An international perspective. Med. Sci. Sports Exercise. 22:2-48, 1990.

14. Hubbard, R.W. and L.E. Armstrong. Hyperthermia: New thoughts on an old problem. Phy. Sports Med. 17(6)97-113, 1989.

15. Hubbard, R.W., P.C. Szlyk and L.E. Armstrong. Influence of thirst and fluid palatability on fluid ingestion during exercise. In: Perspectives in Exercise Sciences and Sports Medicine: Fluid Homeostasis During Exercise. (In Press).

16. Hubbard, R.W. Heatstroke pathophysiology: The Energy Depletion Model. Med. Sci. Sports Exercise. 22:19-28, 1990.

17. Hubbard, R.W. Introduction: The role of exercise in the etiology of exertional heatstroke. Med. Sci. Sports Exercise. 22:2-5, 1990.

18. Matthew, C.B., R.W. Hubbard, and R.P. Francesconi. Atropine, diazepam and physostigmine: Thermoregulatory effects in the heat-stressed rat. Life Sci. 44(25):1921-1927, 1989.

19. Matthew, C.B. Atropine and scopolamine as adjuncts to physostigmine in exercising rats. Proceedings of the 1989 Medical Defense Bioscience Review. 1:407-410, 1989.

20. Matthew, C.B. and C.L. Chapin. Spectrophotometric determination of circulating cholinesterase in rats. Aviat. Space Environ. Med. (In Press).

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PUBLICATIONS:

21. Matthew, W.T., G.J. Thomas, M.Rose, R.W. Hubbard, R. Whang, F.J. Schatzle, J.D. Baldwin, S.A. Hsu, O.K. Huh, F.L. Wuirk. Satellite remote sensing of heat stress during reserve training at Fort Hood. Proceedings of the Ninth Annual Electro-Optical Systems Atmospheric Effects Library/Tactical Weather Intelligence (EOSAEL/TWI) Conference. 1, 1989.

22. Szlyk, P.C., I.V. Sils, R.P. Francesconi, R.W. Hubbard, and W.T. Matthew. Variability in intake and dehydration in young men during a simulated walk. Aviat. Space Environ. Med. 60:422-7, 1989.

23. Szlyk, P.C., I.V. Sils, R.P. Francesconi, R.W. Hubbard, and L.E. Armstrong. Effects of water temperature and flavoring on voluntary dehydration in men. Physiol. and Behav. 45(3):639-647, 1989.

24. Szlyk, P.C. I.V. Sils, R.P. Francesconi, and R.W. Hubbard. Patterns of Human Drinking: Effects of exercise, water temperature and food consumption. Aviat. Space Environ. Med. 61:43-48, 1990.

25. Szlyk, P.C., R.P. Francesconi, I.V. Sils, R. Foutch, and R.W. Hubbard. Effects of chemical protective clothing and masks, and two drinking water delivery systems on voluntary dehydration. USARIEM Technical Report No. T14-89, 1989.

26. Szlyk, P.C., I.V. Sils, W.J. Tharion, R.P. Francesconi, R.B. Mahnke, M.J. Durkot, C.B. Matthew, W.T. Matthew, L.E. Armstrong, T.M. Rauch, and R.W. Hubbard. Effects of a modified through-mask drinking system (MDS) on fluid intake during exercise in chemical protective gear, USARIEM Technical Report No. T1-90, 1989.

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PUBLICATIONS:

27. Szlyk, P.C., I.V. Sils, R.P. Francesconi, and R.W. Hubbard. Effects of MOPP configuration and two drinking systems on fluid balance and performance. Proceedings of the 1989 Medical Defense Bioscience Review, 1:803-806, 1989.

ABSTRACTS:

28. Armstrong, L.E., J. P. DeLuca, E.L. Christensen, and R.W. Hubbard. Evaluation of a temperate environment heat tolerance test by utilizing prior heatstroke patients. FASEB J. 3(4):A531, 1989.

29. Armstrong, L.E., and R. W. Hubbard. Exertional Heatstroke: An International Perspective. Med. Sci. Sports Exerc. 21(2):S1, 1989.

30. DeLuca, J.P., L.E. Armstrong, E.L. Christensen, R.W. Hubbard, J.A. Vogel, and D.D. Schnakenberg. Mass-to-surface area index of heat tolerance: a descriptive study. Med. Sci. Sports Exerc. 21(2) Supplement:5101, 1989.

31. Durkot, M.J., R.P. Francesconi, O. Martinez, D. Caretti, and R.W. Hubbard. The effects of dichloroacetate (DCA) on exercise and thermoregulatory performance in rats. FASEB J. 3(4):991, 1989.

32. Francendese, A., R.P. Francesconi, and R.W. Hubbard. Thermal challenge and lactate transport in isolated red blood cells. J. Cell Biol. 107:568a, 1989.

33. Francendese, A., R.P. Francesconi, M. Durkot, R. Anderson, and R. Hubbard. Glucose oxidation in isolated red blood cells: Effect of heat and exogenous lactate. FASEB J. 3:A700. 1989.

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ABSTRACTS:

34. Francesconi, R.P., C.B. Matthew, R. Anderson and R.W. Hubbard. Anticholinergics: Effects on physical performance and thermoregulation of rats in a warm environment. FASEB J. 3, A990, 1989.

35. Matthew, C.B., R.P. Francesconi, and R.W. Hubbard. Physostigmine - induced cholinesterase inhibition: Dose response effects on running performance of rats. FASEB J. 3, A991, 1989.

36. Sils, I.V., P.C. Szlyk, N. Leva, and R.P. Francesconi. Effects of impermeable clothing on heat indices strain and plasma hormones. FASEB J. 3(4):A702, 1989.

37. Szlyk, P.C., I.V. Sils, R.P. Francesconi, R. Mahnke, and M. Rose. Hypohydration during hot weather training. FASEB J. 3(4):A1252, 1989.

PRESENTATIONS:

38. Armstrong, L.E. Army scenarios and carbohydrate-electrolyte beverage use. Workshop on the use of carbohydrate-electrolyte solutions by soldiers in the field, Committee on Military Nutrition, National Academy of Sciences, Washington, DC, 17 February 1989.

39. Armstrong, L.E. Fluid, electrolyte and carbohydrate needs of athletes. Yale University Conference on Ergogenic Aids, New Haven, CT, March 1989.

40. Armstrong, L.E. Time-course of recovery and heat acclimation ability of prior heatstroke patients. Annual Meeting of American College of Sports Medicine, Baltimore, MD, 31 May 1989.

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PRESENTATIONS:

41. Francesconi, R.P., C.B. Matthew, R. Anderson, N. Leva, L. Gowenlock and R.W. Hubbard. Aprophen and Scopolamine: Metabolic and clinical chemical effects during exercise in a warm environment. Proceedings of the 1989 Medical Chemical Defense Bioscience Review, Columbia, MD, 15-17 August 1989.

42. Hubbard, R.W. Food and Nutrition Board's Committee on Military Nutrition Research Workshop on "Carbohydrate - Electrolyte Fluid Replacement Beverages". Washington, DC, 15 February 1989.

43. Hubbard, R.W., P.C. Szlyk, and L.E. Armstrong. Solute model of cellular energy model.: Practical and theoretical aspects of thirst during exercise, Committee on Military Nutrition, National Academy of Sciences, Washington, DC, 17 February 1989.

44. Hubbard, R.W. Heatstroke pathophysiology: The energy depletion model, and The role of exercise in the etiology of exertional heatstroke. American College of Sports Medicine 1989 Meeting. Baltimore, MD, 30 May - 3 June 1989.

45. Hubbard, R.W. Influence of thirst and fluid palatability on fluid ingestion during exercise. Third annual meeting on perspectives in exercise science and sports medicine. Kauai, HI, 21-28 June 1989.

46. Hubbard, R.W. Mathematical interpretation of the osmotic basis for thirst. Lawrence Livermore National Laboratories, San Francisco, CA, 29-30 June 1989.

47. Matthew, C.B., R.P. Francesconi, and R.H. Hubbard. Atropine and scopolamine as adjuncts to physostigmine in exercising rats. Proceedings of the 1989 Medical Chemical Defense Bioscience Review, Colombia, MD, 15-17 August 1989.

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PRESENTATIONS:

48. Szlyk, P.C., I.V. Sils, R.P. Francesconi, and R.W. Hubbard. Effects of MOPP Configuration and two drinking systems on fluid balance and performance. Proceedings of the 1989 Medical Defense Bioscience Review, Columbia, MD, 15-17 August 1989.

KEY BRIEFINGS:

49. L.E. Armstrong, Ph.D. Life, exercise, and heat illness in hot environments. Seminar series of four lectures to personnel of U.S. Naval Hospital, troops and dependents, Guantanamo Bay, Cuba, 1989.

50. L.E. Armstrong, Ph.D. Heat Illness, dehydration and environmental monitoring. Moore Army Air Field, Ayer, MA, 1989.

51. L.E. Armstrong, Ph.D. Heat illnesses: Diagnosis, treatment, prevention. Flight Surgeon course, Army School of Aviation Medicine, Fort Rucker, AL, 1989.

52. L.E. Armstrong, Ph.D., R.P. Francesconi, Ph.D., W.T. Matthew, B.S., R.W. Hubbard, Ph.D., and P.C. Szlyk, Ph.D. USARIEM Course, Current Concepts in Environmental Medicine, Natick, MA, 1989.

53. M.J. Durkot, Ph.D. Prevention of Heat Injuries, Medical Officers, NCO's and enlisted personnel, US Army Training Center, Fort Dix, NJ, 1989.

54. M.J. Durkot, Ph.D. Heat Injuries and Prevention. Cutler Army Hospital, Ft. Devens, MA, 1989.

55. R.P. Francesconi, Ph.D. Prevention of heat injury during desert operations, LTG Schneider, CG, 5th Army, San Antonio, TX, 1989.

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KEY PRIEFINGS:

56. R.P. Francesconi, Ph.D. Prevention of heat injury during military operations in desert/jungle environments. Presentation to safety officers, 5th US Army, San Antonio, TX, 1989.

57. R.P. Francesconi, Ph.D. Brief COL Dr. Wolf Von Restorff, Zenterales Institut des Sanitatsdienstes, Koblenz, West Germany, during his visit to USARIEM, Natick, MA, 1989.

58. P.C. Szlyk, Ph.D. Heat Injury Prevention. 807th Medical Brigade, Garland, TX, 1989.

SIGNIFICANT VISITORS:

Visit of COL Ralph Shain, MD, and LTC Jacob Atsmon, M.D., Israeli Defense Forces.

Dr. Brian Maxwell Quigley, Visiting Scientist, University of Queensland, Brisbane, Australia.

Dr. Banks and Mr. Palmerton, U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi.

Maj (Dr.) Wye Mun Low and Cpt(Dr.) Suurya Kumar, Singapore Armed Forces, Republic of Singapore.

SIGNIFICANT TDY:

R.W. Hubbard, Ph.D. To meet Mr. Terry Klopcec of Ballistics Research Lab to discuss the evaluation of environmental heat on human performance. Aberdeen Proving Ground, Aberdeen, MD, 5 April 1989.

R.W. Hubbard, Ph.D. To attend meeting on Multiservice Steering Committee for Field Drinking Water. Fort, Detrick, Frederick, MD, 21-13 March 1989.

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SIGNIFICANT TDY:

R.W. Hubbard, Ph.D. To attend the 1989 Medical Defense Bioscience Review presented at the Johns Hopkins University, Columbia, MD, 15 August 1989.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Lawrence E. Armstrong, Ph.D. Adjunct Professor, University of Connecticut, Storrs, CT.

Lawrence E. Armstrong, Ph.D. Executive Board, New England Chapter of American College of Sports Medicine.

Lawrence E. Armstrong, Ph.D. Fluid Replacement During Exercise Position Statement Committee, American College of Sports Medicine.

Lawrence E. Armstrong, Ph.D. Reviewer for four journals, 1989: Aviation, Space Environmental Medicine; International Journal of Sports Medicine; Journal of Applied Sports Science Research; Medicine and Science in Sport and Exercise.

Michael J. Durkot, M.S., Ph.D. Executive Committee Sigma XI, The Scientific Research Society Natick Chapter.

Michael J. Durkot, M.S., Ph.D. Published Book Review of Thermoregulation: research and clinical applications for Aviation Space Environ Med.

Michael J. Durkot, M.S., Ph.D. Reviewer, Aviation Space and Environmental Medicine.

Michael J. Durkot, M.S., Ph.D. Contracting Officer's Representative, USAMRDC, 1989.

Ralph P. Francesconi, Ph.D. Reviewer, Aviation Space and Environmental Medicine, 1989.

HEAT RESEARCH DIVISION

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Ralph P. Francesconi, Ph.D. Reviewer, Journal of Applied Physiology, 1989.

Ralph P. Francesconi, Ph.D. Advisor, National Academy of Sciences/National Research Council Associateship Program, 1989.

Ralph P. Francesconi, Ph.D. Contracting Officer's Representative, USAMRDC, 1989.

Ralph P. Francesconi, Ph.D. Reviewer, Army Research Office, 1989.

Roger W. Hubbard, Ph.D. Adjunct Professor of Pathology, Boston University School of Medicine, Boston, MA.

Roger W. Hubbard, Ph.D. Member, DOD-Water Resource Management Action Group (WRMAG), 1980 to present.

Roger W. Hubbard, Ph.D. Member, DOD-Steering Committee on Field Water Quality.

Roger W. Hubbard, Ph.D. Reviewer, Aviation Space and Environmental Medicine, 1989.

Roger W. Hubbard, Ph.D. Reviewer, Journal of Applied Physiology, 1989.

Roger W. Hubbard, Ph.D. Reviewer, Journal of Wilderness Medicine, 1989.

Patricia C. Szlyk, Reviewer, Aviation Space and Environmental Medicine, 1989.

Patricia C. Szlyk, Science Fair Judge, Mass State Science & Engineering Fair.

HEAT RESEARCH DIVISION

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Patricia C. Szlyk, Ph.D. Admissions Committee, Sigma Xi Honor Society, Natick Chapter.

Patricia C. Szlyk, Ph.D. President-Elect, Sigma Xi Honor Society, Natick Chapter.

MILITARY ERGONOMICS DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

administration, and the second with no medication (CON). PYBr decreased red blood cell cholinesterase by an average of 40 (±7) %. Esophageal (T_{es}) and mean skin temperature ($\bar{T}_{sk}$), forearm blood flow (FBF) and cutaneous perfusion (SkBF) were measured during a 15 min rest period and during 30 minutes of cycle exercise. PYBr decreased heart rate at rest and during exercise at 29°C and 36°C (8 bpm, $P<0.05$). SkBF was decreased at rest (-40%, -30%) and during exercise (-40%, -50%) in PYBr compared to control at 29°C and 36°C, respectively ($P<0.05$). There was no effect of PYR on oxygen consumption. $\bar{T}_{sk}$ was different in the three conditions by design, but was unchanged by PYBr. T_{es} was not different at rest in any condition, but was elevated during exercise at 36°C (0.2°C, $P<0.05$) compared to the other conditions. PYBr increased T_{es} during exercise at 36°C (0.1°C, $P<0.05$). These data indicate that PYBr can increase dry heat gain for soldiers during exercise in the heat. (Publication: 12, 15, 16; Abstract: 47, 48, 55; Key Briefing: 74, 75, 76)

7. The effects of acute oral administration of 30 mg pyridostigmine bromide (PYBr) on thermoregulatory, cardiovascular, and fluid-balance responses of soldiers during two-hour walks in dry and humid heat, and at different levels of body hydration were examined. Five men underwent 8 heat stress tests (HSTs) at 35°C, each consisting of four 25-min treadmill walks (35% $\dot{V}o_2max$) separated by 5-min rests, in 4 conditions: (a) 20% relative humidity (rh), subjects euhydrated and drinking ad libitum; (b) 20% rh, euhydrated; (c) 75% rh, euhydrated; and (d) 20% rh, hypohydrated by 3% of body weight. In conditions 2-4, subjects drank to maintain their pre-HST weight. In each condition we tested subjects once after 30 mg PYBr p.o. (mean inhibition of red cell cholinesterase, 30.8 ± 7.6% (SD) from 90-210 minutes post ingestion) and once after placebo. We measured rectal temperature (T_{es}) and skin temperatures on chest (T_{chest}), upper arm, and calf; heart rate (HR); fluid intake and output; and nude weights. PYBR lowered HR a mean of 3 beats/min ($P=0.004$) overall, most during

MILITARY ERGONOMICS DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. To determine the effects of acute heat stress, heat acclimation and hypohydration on the gastric emptying rate of water during treadmill exercise, ten physically fit men ingested 400 ml of water before each of three bouts of treadmill exercise (~50% $\dot{V}o_2max$) on five separate occasions. Stomach contents were aspirated after each exercise bout. Before heat acclimation (ACC), experiments were performed in a neutral (18°C), hot (49°C) and warm (35°C) environment. Subjects were euhydrated for all experiments before ACC. After ACC, the subjects completed two more experiments in the warm (35°C) environment; one while euhydrated and a final one while hypohydrated (5% of body weight). The volume of ingested water emptied into the intestines at the completion of each exercise bout was inversely correlated ($P<0.01$) with the rectal temperature ($r = -0.76$). The following new observations were made: 1) exercise in a hot (49°C C) environment impairs gastric emptying rate as compared with a neutral (18°C) environment; 2) exercise in a warm (35°C) environment does not significantly reduce gastric emptying before or after heat acclimation; but 3) exercise in a warm environment (35°C) when hypohydrated reduces gastric emptying rate and stomach secretions. Reductions in gastric emptying appear to be related to the severity of the thermal strain induced by an exercise/heat stress. These data indicate that soldiers need to rehydrate before they become dehydrated to maximize fluid availability to the body. (Publication: 22)

2. To examine the gastric emptying characteristics of water during treadmill exercise performed over a wide range of intensities relative to resting conditions, 10 men ingested 400 ml of water prior to each of six exercise bouts or periods of seated rest. Three bouts of walking exercise ($1.57\ m \cdot s^{-1}$) were performed at grades eliciting ~28%, 41% or 56% of $\dot{V}o_2max$. On a separate day three bouts of running ($2.68\ m \cdot s^{-1}$) exercise were performed at grades eliciting ~57%, 65% or 75% of $\dot{V}o_2max$. Gastric emptying was increased during treadmill exercise at all intensities excluding 75% $\dot{V}o_2max$ as compared to rest. Gastric emptying was similar for all intensities during walking, and at 57% and 65% $\dot{V}o_2max$ during

MILITARY ERGONOMICS DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

running. However, running at 75% $\dot{V}o_2max$ decreased the volume of original drink emptied as compared to all lower exercise intensities. Stomach secretions were markedly less during running as compared to walking and rest. These data demonstrate that gastric emptying is similarly increased during both moderate intensity (~28%-65% $\dot{V}o_2max$) walking or running exercise as compared to resting conditions. However, gastric emptying decreases during high intensity exercise. These data indicate that soldiers should rehydrate while performing light to moderate intensity exercise. (Publication: 23)

3. To determine how increases and decreases in plasma tonicity and blood volume influence thermoregulatory control parameters, eleven males attempted Heat Stress Tests (HSTs) in a variety of conditions. Individuals were tested when unacclimated and acclimated to the heat, when euhydrated and hypohydrated as well as before and after erythrocyte/saline infusion. The HSTs consisted of treadmill exercise (325 $W \cdot m^{-2}$) in a hot (35°C, 45% relative humidity) environment, and esophageal temperature and local sweating rate were continuously measured during 25 min of exercise. These experiments resulted in a matrix of conditions where both plasma tonicity and blood volume were increased or decreased relative to control conditions (euhydration, preinfusion). The findings concerning thermoregulatory sweating during exercise in the heat were summarized as follows: 1) acute polycythemia decreases the threshold temperature and increases the sweating sensitivity; 2) both threshold temperature and sweating sensitivity are increased or decreased from control levels dependent on the combined influence of plasma tonicity and blood volume; and 3) equations were developed which describe how plasma tonicity and blood volume alter threshold temperature and sweating sensitivity values. These data provide insight into the relative importance of either re-establishing tonicity or blood volume during rehydration in soldiers. (Publication: 34; Abstract: 52)

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4. The effect of a hypobaric environment on the control of thermoregulatory sweating was studied. Acute exposure of eight subjects to simulated altitude (552 and 428 Torr) decreased the thermosensitivity of arm, chest and leg sweating during both light and moderate intensity exercise. The time to sweating onset and the core temperature threshold for sweating were unaffected during exercise by acute exposure to either moderate or high altitude. Whole body skin wettedness was decreased an average of 23% at high altitude during light and moderate exercise. Skin temperature was unchanged by acute altitude exposure. The increased evaporative heat transfer coefficient reported previously at reduced barometric pressure is consistent with the lower skin wettedness reported in this study. These results indicate that water requirements during exercise at altitude may be higher than at sea level due to increased water loss through the skin. (Publication: 10)

5. To determine the effects of menstrual phase on the control of thermoregulatory sweating, seven women were studied during moderate and severe exercise in hot and extremely hot environmental conditions. The core temperature at which sweating began was higher in the luteal or post-ovulatory phase of the menstrual cycle when body temperature is elevated. There was no difference in thermosensitivity of sweating to increasing core temperature in either environment during moderate or heavy exercise during the menstrual cycle phases studied. These results indicate that thermoregulatory function is different in women during different phases of their menstrual cycle. The increasing roles of women in the military necessitate an improved understanding of potential physiological and performance issues. (Publication: 13, 39)

6. To evaluate the effects of pyridostigmine administration on heat exchange in controlled environmental conditions, four soldiers exercised during six separate experiments in three distinct environments (22°C, 29°C and 36°C) in which the relative humidity was 30%. Two experiments were done in each condition; one, 150 minutes after oral (30 mg) pyridostigmine bromide (PYBr)

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hypohydration. In condition 2, T_{chest}) decreased more during exercise, and the T_{re}-T_{chest} gradient widened more, with PYBr. PYBr reduced the rise in T_{re} during exercise in the hypohydrated state. PYBr tended insignificantly to increase sweating in all environments, and had no significant effect on plasma volume, osmolality, ad libitum drinking, O_2 consumption, or subjective ratings of temperature discomfort, or exertion. PYBr had little effect on soldiers' tolerance to moderate exercise-heat stress, and did not aggravate the strain of hypohydration. (Publication: 42)

8. To characterize changes which might occur in respiratory and/or skeletal muscle function following a single 30 mg oral dose of pyridostigmine bromide, ten males participated in a battery of pulmonary function tests on two control days (CON) and on two test days 120 minutes after ingesting 30 mg oral pyridostigmine bromide (PYBr). Red blood cell cholinesterase was inhibited an average of 37 (±10) % by PYR ingestion. Seven of these volunteers performed four tests of skeletal muscle strength or endurance on one day 240 minutes after PYBr ingestion and on a control day. Red cell cholinesterase was decreased by an average -4 (±8) % by PYBr in these subjects. There was no difference in forced vital capacity, forced expiratory volume (1 sec), maximal voluntary ventilation, maximal inspiratory or expiratory flow, or carbon dioxide sensitivity between CON and PYR or between the two CON experiments or the two PYBr experiments. There was no difference in peak torque generated during leg extension at 30 or $180° \cdot min^{-1}$, peak hand grip strength or hand grip endurance between CON and PYBr. Enzyme markers of muscle tissue damage, creatine kinase, serum transaminase and lactate indicate that respiratory and skeletal muscle function are not affected by a single oral dose of PYBr; however, these results should not be extrapolated to include repetitive or chronic doses of PYBr.

9. This investigation studied the importance of muscle glycogen levels for body temperature regulation during cold stress. Physiological responses of eight euglycemic males were measured

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while they rested in cold (18°C, stirred) water on two separate occasions. The trials followed a 3-day program of diet and exercise manipulation designed to produce either high (HMG) or low (LMG) preimmersion glycogen levels in the muscles of the legs, arms and upper torso. Preimmersion vastus lateralis muscle glycogen concentrations were lower during the LMG trial (144 ± 14 mmol glucose/kg dry tissue) than the HMG trial (543 ± 53 mmol glucose/kg dry tissue). There were no significant differences between the two trials in shivering as reflected by aerobic metabolic rate or in the amount of body cooling as reflected by changes in rectal temperature during the immersions. Postimmersion muscle glycogen levels remained unchanged from preimmersion levels in both trials. Small but significant increases in plasma glucose and lactate concentration occurred during both immersions. Plasma glycerol increased during immersion in the LMG trial but not in the HMG trial. Plasma free fatty acid concentration increased during both immersion trials, but the change was apparent sooner in the LMG immersion. It was concluded that thermoregulatory responses of moderately lean and fatter individuals exposed to cold stress were not impaired by a substantial reduction in the muscle glycogen levels of several major skeletal muscle groups. Furthermore, the data suggest that, depending on the intensity of shivering other metabolic substrates are available to enable muscle glycogen to be spared. Therefore, glycogen depletion does not impose a thermoregulatory problem for soldiers exposed to the cold. (Publication: 44; Abstract 57)

10. A human biophysical study was conducted to evaluate the relative efficacy of a lightweight chemical protective garment in comparison to the U.S. standard issue overgarment. There were significant differences between the UK MK-IV and issue Battledress Overgarment suits in MOPP 4 configuration during exercise (3 Met) at 65°F, 70%rh, 90°F, 50%rh, and 90°F, 80%rh in rate of change of body temperature and sweating properties. Less physiological strain was exhibited while wearing the MK-IV garment. Endurance

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times were also significantly different in both 90°F environments. All responses indicated that subjects performed better while wearing the MK-IV garment. (Publication: 7)

11. Work continued in the evaluation of intermediate cold weather glove prototypes. Subjects wearing a new intermediate cold weather glove with a (polytetrafluorethylene, PTFE) moisture barrier and a synthetic liner performed significantly better, in terms of allowing soldiers' longer sitting endurance times (59 vs. 42 min) and lessening mean finger temperature decreases (-0.40 vs. -0.61°C·min^{-1}), relative to their responses while wearing the current issue light duty (LD) glove during a walk/sit test evaluation. (Publication: 8)

12. A study was done on the evaluation of LD gloves. Nc significant differences were found between the current issue LD glove with a wool/nylon liner and two new gloves having a leather shell and two variations of synthetic liners when both were evaluated in the dry state. However, when exposed to moisture prior to testing, there was a significant decrease in soldiers' endurance times during exercise exhibited in one of the new prototype gloves. That latter observation can be attributed to increased leakage through the new shell material.

13. Additional work on handwear insulation evaluation continues with the use of a thermal aluminum hand model. The new aluminum hand model was run bare and with the trigger finger and LD gloves. Total insulation (I_t) values for the gloves were approximately 0.10 clo lower than previous measurements made with a copper model. The differences are, in part, attributable to differences in resistance values in the air space under the gloves in the palm region of the models.

14. Extensive use of the heat strain prediction model continues. Estimated cooling times and rectal temperatures, water intake, and potential casualty rates at cool down were predicted for an Air

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Force standard for MOPP 4 configuration. From these prediction times based on work rate cycles and garment insulation values provided, and their own modeling activity, the Air Force anticipates that they will refurbish their old standard.

15. A microclimate cooling computer program was developed from several database cooling vest studies at USARIEM and rational heat transfer principles. The potential for prediction of excessive cooling and heating of body parts when various air cooling rates, work rates and garment configurations is forthcoming which will help the user in knowing heat strain limits with various vest systems. (Publication: 6)

16. A copper manikin study was completed to determine if layers of the current Extended Cold Weather Clothing System (ECWCS) can be replaced without adversely affecting thermal insulation values. The potential for evaporation through various replacement layers and the absolute thermal insulation showed little difference in comparison to the conventional system. This has greater bearing in reducing cost of the conventional system for troops after more extensive wear tests are conducted.

17. A biophysical study was conducted to define the useful ranges of cold-dry air temperatures for specific handwear to be worn with the ECWCS. A multiple correlation analysis equation based on metabolism, rectal, and skin temperatures was developed as a useful predictor of endurance time (ET) while wearing the ECWCS with various handwear including the current issue. Middle finger temperature was a distinct forcing factor reducing ET regardless of type of glove. (Publication: 8)

18. A study done during heavy intermittent treadmill exercise with MOPP 4 indicated that rectal temperature and esophageal temperature tracked the physiological strain equally well over the whole period of work. A non-thermoregulatory component, associated possibly with changes present in skin blood flow or skin conductance, was

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also observed as a distinct component in heavy intermittent work.

19. A study was completed employing flush mounted naphthalene disks in the articulated manikin and mass transfer analogy to ascertain convective heat transfer as a function of wind speed. It was discovered that a new coefficient (the logarithmic mean density factor, P_{AM}) in the conventional Chilton-Colburn j-factor analogy between heat and mass transfer cannot be regarded as equivalent to 1. For naphthalene-air environments, the $P_{AM,n}$ is rather close to 0.319. This is an important coefficient which will allow us to determine heat transfer coefficients close to the skin with various clothing configurations thereby making model predictions of heat loss at various environments with wind much more reliable. (Publication: 3,4; Abstract: 46)

20. A new reference method for evaluation of sleeping bags was initiated. The previous method, albeit reliable, has the possibility of introducing excessive heat sinks particularly on the sites in close contact with the floor surfaces where the copper manikin lies supine. A standard non-metallic reference cot and more temperature sites, along with more rigorous temperature control of the environmental chamber, shall be used. The comparison with the original reference standard has begun. The means of a more rigorous method of sleeping bag evaluation from various contractors is now assured.

21. A human physiological evaluation of waterproof/breathable combat handwear was complcted. Combat gloves lined with either polytetrafluoroethylene, polyethylene, or polyurethane were worn in a cold stress test (-9.5°C, 20%rh). The effect of wind speed (10 mph) and wetting of the exterior of the gloves lowered the soldiers' endurance time significantly. Prediction equations to establish an optimum combination based from new man-made materials and work-rest cycles in extension of endurance times is a likely output in the near future.

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22. Performance evaluation of the new Hohenstein Thermoregulatory Model of the Human Skin was conducted using control samples of open-cell foam provided as a standard with the model plate. Values of resistance to heat transfer and water vapor transfer were generally close to those obtained at the Hohenstein Institute, indicating that there was no damage of the system in its transit. A comparative evaluation of several underwear fabrics tested on both the skin model and the old USARIEM sweating flat plate apparatus indicted that the USARIEM thermal insulation values generates clo values some 30% higher than those obtained from the Hohenstein plate. (Publication: 6)

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82. Kent B. Pandolf, Ph.D. Physical stress at the environmental extremes of heat, cold and high altitude; Advanced Course at Army War College, Carlisle Barracks, PA, April 1989.

83. W. Keith Prusaczyk, CPT, Ph.D. NBC respiratory protective equipment to be fielded by the year 2000; RESPO-21 Meeting, Edgewood Arsenal, MD, February 1989.

84. W. Keith Prusaczyk, CPT, Ph.D. Design considerations for NBC protective equipment to be fielded in the 21st century; CRDEC/Natick IPD Design Workshop, Aberdeen, MD, October 1989.

85. Michael N. Sawka, Ph.D. Interaction of water bioavailability, thermoregulation and exercise performance; National Academy of Sciences, Washington, D.C., February 1989.

86. Michael N. Sawka, Ph.D. Physiology of microclimate cooling; Joint Service Microclimate Cooling Program Review, U.S. Army Natick Research, Development and Engineering Center, Natick, MA, February 1989.

87. Lou A. Stephenson, Ph.D. Effects of sleep deprivation on thermoregulation; P^2NBC^2 Test and Scientific Advisory Group, Fort McClellan, AL, January 1989.

88. Lou A. Stephenson, Ph.D. Effects of sleep deprivation on control of thermoregulation; CONOPS/Stress Management Working Conference, Fort Benjamin Harrison, IN, August 1989.

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SIGNIFICANT TDY:

Richard R. Gonzalez, Ph.D. To attend the Laboratory Program Representatives meeting of the National Research Council which is in charge of National Research Council Fellows for the Department of the Army, Washington, DC, 6-11 April 1989.

Richard R. Gonzalez, Ph.D. To the 15th Commonwealth Defence Conference on Operational Clothing and Combat Equipment as the US representative. Ottawa, Canada, 14-26 May 1989.

Richard R. Gonzalez, Ph.D. To the American Society of Heating Refrigeration and Air-Conditioning Engineers to serve as a member of their Indoor Environmental Room Standards Committee, Vancouver, Canada, 12 June-7 July 1989.

Richard R. Gonzalez, Ph.D. To the International Thermal Physiology Symposium to attend the sessions and present a paper, Tromso, Norway, 7-21 July 1989.

Margaret A. Kolka, Ph.D. To present a paper at the Thermal Physiology Satellite Symposium, International Union of Physiological Sciences, Tromso, Norway, 14-21 July 1989.

Margaret A. Kolka, Ph.D. To present a paper at the Israel Bilateral Medical Research and Development Symposia, Shoresh, Israel, 10-17 November 1989.

Clement A. Levell. To serve as USARIEM representative on clothing/heat stress evaluation of the IME CB overgarment at the International Material Evaluation (IME) Meeting, Fort Benning, GA, 4-5 April 1989.

Leslie Levine. To participate in 3rd Scandinavian Symposium on Protective Clothing Against Chemicals and other Health Risks, Norwegian Defence Research Establishment, Kjellor, Norway, 24 September-4 October 1989.

MILITARY ERGONOMICS DIVISION

SIGNIFICANT TDY:

Leslie Levine. To participate in STEPO Final Phase I design review meeting, GEOMET Technology, Gaithersburg, MD, 30 October-2 November 1989.

W. Keith Prusaczyk, CPT, Ph.D. To participate in Mission Degradation Meeting in support of RESPO 21 effort to develop NBC respiratory protective equipment to be fielded by the year 2000, Edgewood Arsenal, MD, 21-23 February 1989.

W. Keith Prusaczyk, CPT, Ph.D. To participate in Individual Protection Design Workshop I as part of RESPO 21, U.S. Army Chemical Research and Engineering Center, Aberdeen, MD, 10-12 October 1989.

William R. Santee, Ph.D. To present a paper on the performance of protective clothing to the International Symposium on Protective Clothing, San Diego, CA, 15-18 January 1989.

Michael N. Sawka, Ph.D. To participate in symposium on carbohydrate-electrolyte solutions for fluid replacement, National Academy of Sciences, Washington, D.C., 15-17 February 1989.

Michael N. Sawka, Ph.D. To chair and participate in symposium on upper body exercise: physiology and practical considerations, American College of Sports Medicine Meeting, Baltimore, MD, 30 May-3 June 1989.

Michael N. Sawka, Ph.D. To participate in Quaker Conference Symposium on fluid homeostasis during exercise, Quaker Sports Medicine Review Board, Kauai, HI, 19-30 June 1989.

Michael N. Sawka, Ph.D. To participate as Westinghouse Lecturer in the Symposium on Problems in Sports Medicine, Texas American College of Sports Medicine Meeting, College Station, TX, 26-29 October 1989.

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SIGNIFICANT TDY:

Lou A. Stephenson, Ph.D. To propose research to validate the use of temperature/sensor pill with esophageal and rectal temperature as an index of core temperature to the P^2NBC^2 Joint Working Group, Fort McClellan, AL, 15-17 May 1989.

Lou A. Stephenson, Ph.D. To participate as an invited speaker to CONOPS/Stress Management Working Conference, Indianapolis, IN, 25 August-4 September 1989.

Andrew J. Young, Ph.D. To participate in symposium at the 31st International Congress of Physiological Sciences, Helsinki, Finland, 7-14 July 1989.

Andrew J. Young, Ph.D. To participate in 29th Meeting of the Air Standardization Coordinating Committee's Working Party 61, RAAF Base Fairbairn, Canberra, Australia, 24 October-2 November 1989.

SIGNIFICANT VISITORS:

Dr. Douglas Bennett, Program Director, Batelle Research Institute, Richland, WA.

Dr. Barbara Fetch, Chief Materials Research, Batelle Research Institute. Richland, WA.

Dr. Donald Holness, Liaison Officer, Research R&D, Canadian Liaison Staff, Washington, D.C.

Drs. R. Ilmarinen and T. Seppala, Department of Physiology, Institute of Occupational Health, Helsinki, Finland.

Dr. Stephen C. Jacobsen, Director, Center for Engineering Design, College of Engineering, University of Utah, Salt Lake City, UT.

MAJ S. K. Low. M.D.,PhD., Singapore Armed Forces Team, Sports Medicine Institute, Singapore.

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SIGNIFICANT VISITORS:

Dr. Kenneth C. Parsons, Human Modelling Group, Department of Human Sciences, University of Technology, Loughborough, Leicestershire, United Kingdom.

Dr. Anthony J. Sargeant, Department of Exercise Physiology and Health Science, University of Amsterdam, Academic Medica Centre, The Netherlands.

M.A. Schreiber, Dipl. Ing., Armed Forces Materials Laboratory, Erding, Federal Republic of Germany.

COL Wulf von Restorff, M.D., Ph.D., Central Institute of the Army Medical Service, Koblenz, Federal Republic of Germany.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Richard R. Gonzalez, Ph.D. Standards Preparation Committee (SPC 55-81R) Member, American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

Richard R. Gonzalez, Ph.D. ASHRAE Representative to the American National Standards Institute (ANSI) International Standard ISO/DIN, Ergonomics: Evaluation of thermal strain by physiological measurements.

Richard R. Gonzalez, Ph.D. Member NATO PANEL VIII, Research Study Group 20: Human Modelling of Cold Exposure.

Richard R. Gonzalez, Ph.D. Adjunct Professor, Environmental Science and Physiology, Harvard School of Public Health, Harvard Medical School, Boston, MA.

Margaret A. Kolka, Ph.D. Member, U.S. Army Medical Research and Development Command Steering Committee for Multichambered Autoinjector, Fort Detrick, Frederick, MD.

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PROFESSIONAL APPOINTMENTS/ACTIVITIES:

Margaret A. Kolka, Ph.D. Member, Tri-Service Working Group, JWGD[3] to develop drug screening program, U.S. Army Medical Research and Development Command, Fort Detrick, Frederick, MD.

Kent B. Pandolf, Ph.D., Adjunct Professor of Health Sciences, Department of Health Sciences, Sargent College of Allied Health Professions, Boston University, Boston, MA.

Kent B. Pandolf, Ph.D., Adjunct Clinical Professor of Sports Biology, Springfield College, Springfield, MA.

Kent B. Pandolf, Ph.D., Editor, Exercise and Sport Sciences Reviews.

Kent B. Pandolf, Ph.D., Editorial Board Member, Ergonomics.

Kent B. Pandolf, Ph.D., Member, Publications Committee, American College of Sports Medicine, Indianapolis, IN.

Michael N. Sawka, Ph.D. Adjunct Associate Professor, Physical Therapy, Institute of Health Professions, Massachusetts General Hospital, Boston, MA.

Michael N. Sawka, Ph.D. Member, Nuclear Biological Chemical Protective Equipment Subgroup, Chemical Defense Technical Cooperation Program.

Michael N. Sawka, Ph.D. Member, Research Awards Committee, American College of Sports Medicine, Indianapolis, IN.

Michael N. Sawka, Ph.D. Member, Position Statement Committee on Fluid Replacement During Exercise, American College of Sports Medicine, Indianapolis, IN.

C. Bruce Wenger, Ph.D., M.D. Visiting Research Associate in Physiology, School of Public Health, Harvard University.

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PROFESSIONAL APPOINTMENTS/ACTIVITIES:

C. Bruce Wenger, Ph.D., M.D. Member, Subcommittee C95.1-IV, Working Group 11 (Metabolism/Thermoregulation), American National Standards Institute, New York, NY.

Andrew J. Young, Ph.D. Member, Editorial Board, Medicine and Science in Sports and Exercise, Indianapolis, IN.

Andrew J. Young, Ph.D. Chairman, Public Information Committee, American College of Sports Medicine, Indianapolis, IN.

Andrew J. Young, Ph.D. Member, Publications Committee, American College of Sports Medicine, Indianapolis, IN.

MILITARY NUTRITION DIVISION

SIGNIFICANT RESEARCH FINDINGS/DEVELOPMENTS:

1. Part I of a three-phase evaluation of cold weather feeding under Ration Sustainment Testing was implemented in 1989. The DCSLOG established a task force (DOD Food Task Force 2000) to advise the U.S. Army on improving the current field feeding system. The Task Force recommended that there was an urgent need to field a food item supplemental packet to enhance the acceptability of earlier versions of the Meal, Ready-to-Eat (MRE) and subsequently serve as a calorie supplement for newer versions of the MRE in a cold weather environment. The Surgeon General of the Army would not approve the use of this supplemental packet until it was established that its use would not adversely impact upon soldier nutrient intakes from the MRE. In order to determine the suitability of using this 700 kcal food supplement packet to enhance the acceptability and nutritional intake of both older and newer versions of the MRE, a 10-day field trial was conducted with two companies from the 1st and 2nd BN, 17th Infantry, 6th Infantry Division (Light) during a winter field evaluation exercise at Fort Greely, AK during the first two weeks of March 1989. Temperatures ranged from -40°F to +30°F during this study. Four groups (N=35) with similar activity patterns were assessed. One group was given 4 MRE VI per day; the second, 3-1/2 MRE VIII; the third, 3 MRE VI plus 1 supplemental packet; and the fourth, 3 MRE VIII plus 1 supplemental packet. All groups received a similar amount of calories per day (approximately 4500 kcal). Energy intake was 27 to 40 percent higher in groups receiving the supplemental packets, due in part to the high level of acceptability and consumption of the food items in the supplemental packet and due in part to a 4 to 11 percent increase in consumption of the MRE itself. These results indicated that not only does food consumption increase when the supplemental packet is issued, but also that this consumption can be attributed to both the consumption of the supplemental packet and the MRE itself. Total nutrient intakes were not adversely affected (in fact they were enhanced in many instances) by the supplemental packet. The new, improved MRE VIII was superior to the older MRE VI, and the supplemental packet was a good cold-weather calorie supplement. The results of this study could potentially lead to savings of approximately $1.70 per man per day (savings from issuing three MRE's plus a supplemental

packet versus issuing four MRE's) during cold weather operations. Although caloric intakes in all four groups fell short of the Military Recommended Dietary Allowance (MRDA), the results demonstrate that in a cold environment three MRE's with a supplemental packet are the most effective feeding combination tested to date. The results, from a nutritional standpoint, now provide The Surgeon General of the Army with data to decide if the supplemental pack should be authorized. (Publication: 1,2,4,5)

2. The Ration, Lightweight (RLW) is a newly developed field ration designed to be utilized by Special Operation Forces (SOF) for low to moderate activity scenarios where resupply is not logistically feasible. The calorically dense RLW is relatively high in fat (47% of the kcal). Previous studies at high altitude have indicated that this level of fat may not be optimal for work at high altitude. Two studies, one short term (Mt. Rainier) and one long term (Pike's Peak), were conducted in 1989 to test the suitability of the RLW with a carbohydrate supplement for high altitude operations. A six-day field test was conducted to measure the energy expenditures, activity levels, and nutrient intakes of unsupported SOF soldiers consuming the RLW with a liquid carbohydrate (CHO) supplement during a strenuous field exercise at high altitude (7,000 to 11,000 feet). The field study was conducted at Mt. Rainier National Park, Washington, from 19-23 March 1989. Ten SOF soldiers (age 32±5 years, ht 179.5±6.7 cm, wt 81.2±9.7 kg, and body fat 18.9±8.3%; mean±SD) consumed the RLW and a liquid CHO supplement exclusively for six consecutive days. The soldiers practiced ski-mountaineering, identification of hazardous snow conditions, small unit and advanced movement skills, and cold weather survival techniques for five days. On day six, subjects returned to Fort Lewis because of severe weather conditions but remained on the ration and beverage supplement until post testing could be completed. Body composition measurements (anthropometry and hydrostatic weighing), activity levels (ambulatory monitors), food and water intakes (standard log book technique), and ration and supplement acceptability (post study questionnaire) were recorded. Mean caloric intake (including that from the CHO supplement) for the six-day FTX was 2467±384 kcal/day (12% protein, 34% fat and 54% CHO). Mean energy expenditure using the intake/balance method was 4294±1276 kcal/day. Body weight loss

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averaged 1.7±0.7 kg with 35 percent from fat free mass and 65 percent from fat mass. Total fluid intake was 3.5 L/day. Carbohydrate intake from the beverage supplement was 103±44 g/day (412 kcal/day). This additional carbohydrate helped restore/maintain body glycogen stores and probably reduced potential decrements in physical performance. The results of this study demonstrated the practicability of a CHO supplement to military rations for high altitude operations. This supplement can improve soldiers' hydration status and reduce the loss of lean body mass during acute periods of caloric inadequacy. Even though the RLW was issued at the rate of 4000 kcal/man/day, the soldiers consumed only one half that amount. Similar results have been reported utilizing the MRE. The RLW appeared no more effective than the MRE at high altitude but was considerably lighter to carry. These results indicate that the RLW could be used for short-term, high-altitude operations if a carbohydrate supplement is also issued. (Publication: 1,2,3,4; Abstract: 16,18,19,20)

3. During the period 10 July to 26 July 1989, a 16-day field test of the RLW was conducted at Pike's Peak, Colorado, elevation 14,110 feet. The experiment was designed to compare the performance and nutrient intakes of subjects consuming the RLW with and without a carbohydrate (CHO) supplement for a longer period of high-altitude operations. Sixteen SOF soldiers from two mountain teams from Fort Lewis, Washington, served as test subjects. All of the subjects consumed the RLW *ad libitum* during the 16 days' residence at altitude. Additionally, using a single-blind design, the subjects were required to drink 2 liters/day of a beverage containing either 300 g maltodextrin (1140 kcal; n=8) or placebo (0 kcal; n=8). Ration consumption data was captured by weekly food diaries. Two interim plus final acceptance/opinion questionnaires were administered. Initial heights, body weights, and body compositions by hydrostatic weighing were obtained at sea level during the week prior to transport to Pike's Peak. Final body weights and hydrostatic weights were determined immediately following descent to 6000 ft. Although the subjects conducted special operations and individual skills training as well as participating in exercise testing, many of the subjects were relatively sedentary during the study period. Mean (±SE) daily energy intakes during the 16 days at altitude were 1626±97 kcal for the placebo group and

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2260±58 kcal for the CHO supplemented group. The CHO intakes were higher for the supplemented group, with the mean daily difference between groups being 198 g (385±73 vs 187±143 g; $p<0.001$). Protein intakes were 55±2.8 g and 64±3.7 g, respectively, for the CHO and placebo group. There were trends toward reduced vitamin and mineral intakes in the CHO supplemented group compared to the placebo group. Mean intakes of thiamin, riboflavin, vitamins C, A, and E, calcium, magnesium, and zinc did not meet the MRDA's in either group. Both groups lost an undesirable amount of body weight, 7.2% and 6.3% in the placebo and CHO group, respectively. Although not statistically significant, the placebo group lost more fat-free mass than the supplemented group. Fifty-three percent of the weight loss in the placebo group was fat-free mass, while only 27 percent of the weight lost by the CHO supplemented group was from fat-free tissue. The subjective comments and criticisms of the subjects, combined with the data of inadequate nutrient intakes, indicates that the RLW as currently formulated should not be utilized for long-term high altitude operations. A separate CHO supplement helps improve total energy and carbohydrate intake; however, the potential increase in caloric intake from the supplement will be minimized because of an offsetting reduction in consumption of the ration. If the supplement is not fortified with protein, vitamins, and minerals, nutritional status may be compromised rather than enhanced over long-term (greater than 10 days) usage. The results of these two high altitude studies utilizing the RLW and a carbohydrate supplement demonstrate that, if necessary, the RLW can be used for relatively short-term high altitude operations where weight carried is critical. It does not, however, appear to be palatable enough to encourage adequate caloric intakes for operations lasting longer than 5-6 days. A carbohydrate supplement helps but does not solve the problem of inadequate energy intakes with this ration. (Publication: 1,3,4; Abstract: 16,18,19,20)

4. A study to support the "Lightening of the Soldier Load" initiative of the U.S. Army was begun in 1989 and will continue during 1990. This study was designed to test the concept that the carbohydrate composition of the diet fed to soldiers can exert an influence on the perceived exertion experienced during heavy loadbearing work. Eight test subjects were recruited and assigned

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to diets with nutrient compositions recommended by the Military Nutrition Division and produced by the Food Engineering Directorate of the U.S. Army Natick Research, Development and Engineering Center (Natick). These diets were produced in the form of calorie dense food bars and contained 250, 400, or 550 grams of carbohydrate per day. Test subjects carried packs containing 100 pounds for 8-12 mile marches each day for three days prior to a treadmill pack test. Perceived exertion was recorded every 15 minutes throughout the walk to exhaustion. Aspects of mental performance and marksmanship were also evaluated during and after the treadmill pack test. Preliminary results (pending the testing of additional subjects in 1990) indicated that there were significant diet (low versus high carbohydrate) effects on lower extremity perceived exertion ratings and that there was a significant diet and speed-of-target acquisition interaction. These preliminary results indicate that diet may exert significant influences upon the performance of mental and physical tasks during and following heavy load bearing work. The results of this study may afford the soldier a method to reduce, in a small but significant manner, the perceived weight carried in his pack without leaving any of it behind. An additional eight test subjects will be tested in 1990 to confirm these initial results. (Publication: 4; Abstract: 21)

5. The Military Nutrition Division assists The Surgeon General of the Army by monitoring the effects of the military rations and feeding programs on the health of the soldier. One of the major responsibilities is to determine if soldiers are consuming adequate quantities of food nutrients to meet the MRDA specified in AR40-25. To make these determinations, nutrient intake assessments are periodically conducted on soldiers eating and working in a garrison environment and in the field. A broad-based computerized nutrient analysis system was required to encompass the determination of nutrient composition for both civilian and military foods to support these assessments. The Computerized Analysis of Nutrients (CAN) system, was developed to provide the means for the Military Nutrition Division (MND) staff to analyze dietary intake data for studies conducted on soldiers eating and working in a garrison environment or in the field. The system includes a nutrient data base, recipe analysis component, nutrition

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data entry programs, food consumption analysis and additional data entry software and programs. The nutrient data base of the CAN system is comprised of the most recent data from USDA Handbook 8 information and from the Continuing Survey of Food Intakes by Individuals. Nutrient data from Natick are also included for military-unique ration components. The recipe analysis section permits the user to analyze recipes. However, the CAN system is different from most other food analysis systems in that the USDA retention factors can be applied to estimate nutrient losses during cooking, increasing the accuracy of nutrient intake determinations. The nutrition data entry programs include a diet history program that is used to code the foods, including recipes or individual items consumed over a period of time and a universal data entry program that can be customized for a specific research study. The food consumption program integrates the collected food intake data with the information in the nutrient data base. Data entry programs have also been developed to enter additional information such as biochemical or acceptability data collected during MND research studies. Additional software and programming have been designed for other required applications such as running the statistical analyses of the data and making comparisons of nutrient intakes with the MRDA. The CAN system has the most complete data set of nutrients and is the most versatile nutrient analysis system for research studies in the Armed Forces. It permits rapid and accurate assessments of solider nutrient intakes. This assists The Surgeon General of the Army to periodically monitor the nutrient intakes of selected military populations in accordance with AR 40-25. (Publication: 7,8,9,10,12,12,15; Abstract: 23,24,25,26)

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1. Askew, E.W. Nutrition and performance under adverse environmental conditions. In: Nutrition in Exercise and Sport. J.F. Hickson and I. Wolinsky (Eds.), CRC Press, Boca Raton, FL, 1989, pp. 367-384.

2. Askew, E.W. Nutrition for a cold environment. Phys. Sportsmed. 17:77-89, 1989.

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3. DeLany, J.P., D.A. Schoeller, R.W. Hoyt, E.W. Askew, and M.A. Sharp. Field use of $D_2^{18}O$ to measure energy expenditure of soldiers at different energy intakes. J. Appl. Physiol. 67:1922-1929, 1989.

4. Edwards, J.S.A. (Ed.), Final Report, NATO Panel 8, Research Study Group 8, Nutritional Aspects of Military Feeding, 1989.

5. Edwards, J.S.A., D.E. Roberts, T.E. Morgan, L.S. Lester. An evaluation of the nutritional intake and acceptability of the Meal, Ready-to-Eat consumed with and without a supplemental pack in a cold environment. USARIEM Technical Report No. T/18-89, 1989.

6. Fulco, C.S., P.B. Rock, L.A. Trad, M.S. Rose, V.A. Forte, P.M. Young, A. Cymerman. The effect of caffeine on endurance time to exhaustion at high altitude. USARIEM Technical Report No. T/17-89, 1989.

7. Roberts, D.E., B.J. McGuire, M.S. Rose, D.B. Engell, and C.A. Salter. The role of water availability on consumption of the Ration, Cold Weather. USARIEM Technical Report No. T/13-89, 1989.

8. Rose, M.S. Between-meal food intake for reservists training in the field. USARIEM Technical Report No. T/15-89, 1989.

9. Rose, M.S., P. Szlyk, R. Francesconi, L. Armstrong, W. Matthew, D. Engell, D. Schilling, and R. Whang. Acceptability and effectiveness of nutrient solutions in enhancing fluid intake in the heat. USARIEM Technical Report No. T/10-89, 1989.

10. Rose, R.W., C.J. Baker, W. Wisnaskas, J.S.A. Edwards, and M.S. Rose. Dietary assessment of U.S. Army basic trainees at Fort Jackson, SC. USARIEM Technical Report No. T/6-89, 1989.

11. Smith, D.J., J.S.A. Edwards. Nutrient requirements and recommendations for military personnel. Institute of Naval Medicine, Gosport, England. Technical Report 25/88, 1989.

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12. Szeto, E.G., J.A. Gallo, and K.W. Samonds. Passive nutrition intervention in a military-operated garrison dining facility Fort Devens II. USARIEM Technical Report No. T/7-89, 1989.

13. Szeto, E.G. Nutrition recognized as readiness fuel. Troop Support Digest, 14(1):17-18, 1989.

14. Young, A.J., M.N. Sawka, P.D. Neufer, S.R. Musa, E.W. Askew, and K.B. Pandolf. Thermoregulation during cold water immersion is unimpared by low muscle glycogen levels. J. Appl. Physiol. 66:1809-1816, 1989.

15. Young, P.M., M.S. Rose, J.R. Sutton, H.J. Green, A. Cymerman, C.S. Houston. Operation Everest II: plasma lipid and hormonal responses during simulated ascent of Mt. Everest. J. Appl. Physiol. 66(3):1430-1435, 1989.

ABSTRACTS:

16. Askew, E.W., G.M. Hashiro. Carnitine excretion during thirty days of moderate caloric restriction in non-obese humans. FASEB J., 3(3)A941, 1989.

17. Fulco, C.S., P.B. Rock, L.A. Trad, M.S. Rose, V.A. Forte, Jr., P.M. Young, and A. Cymerman. The effect of caffeine (CAF) on endurance time to exhaustion (ETX) at high altitude (HA). FASEB J. 3:A987, 1989.

18. Hoyt, R.W., E.W. Askew, H.R. Lieberman, J.P. DeLany, D.A. Schoeller, and V.S. Hubbard. Use of the doubly labeled water energy expenditure technique to evaluate combat rations and soldier performance in the field. Fourth Conference for Federally Supported Human Nutrition Research Units and Centers, prepared by the Interagency Committee on Human Nutrition Research, National Institutes of Health, 1989.

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19. Hoyt, R.W., T.P. Stein, H.L. Lieberman, T.E. Morgan, E.J. Iwanyk, E.W. Askew, and A. Cymerman. Doubly Labeled Water (DLW) method accurately estimates energy expenditure during field operations. Sixth International Hypoxia Symposium. Ontario, Canada, 21-25 February 1989.

20. Lieberman, H.R., E.W. Askew, and R.W. Hoyt. Changes in plasma tyrosine and other amino acids due to consumption of a calorie deficient diet for 30 days. FASEB J. 3(3):A463, 1989.

21. Morgan, T.E., R.W. Hoyt, M.J. Durkot, J.L. Briggs, M.S. Rose, and E.W. Askew. Metabolic effects of supplementing a hypocaloric diet with fat. FASEB J. 3(3):A448, 1989.

22. Morgan, T.E., S.H. Laramee. Enteral alimentation: Pump-controlled nutrient infusion. J. Am. Diet. Assoc. 89:A62, 1989.

23. Rose, M.S., P.C. Szlyk, R.P. Francesconi, L.S. Lester, A. Cardello, R. Popper, and R. Whang. Acceptability of nutrient solutions in the heat. FASEB J. 3(4):A1252, 1989.

24. Rose, R.W., C.J. Baker and M.S. Rose. Dietary assessment of U.S. Army basic trainees. Supplement to the J. Am. Diet Assoc. A99, 1989.

25. Rose, R.W., T.E. Morgan, M.S. Rose, G.S. Berenson, S.R. Srinivasan, and E.W. Askew. Blood lipid levels and related coronary heart disease risk factors among U.S. Army basic trainees. FASEB J. 3(3):A655, 1989.

26. Szeto, E.G. Passive nutrition intervention in an Army garrison dining facility. FASEB J. 3(3):A652, 1989.

27. Szlyk, P.C., I.V. Sils, R.P. Francesconi, R. Mahnke, and M. Rose. Hypohydration during hot weather training. FASEB J. 3(4):A1252, 1989.

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PRESENTATIONS:

28. Askew, E.W. Current activities in the cooperative program between LSU and USARIEM. Committee on Military Nutrition Research at NAS, 2001 Wisconson Ave, NW, Washington, DC, May 1989.

29. Askew, E.W. Nutrition and performance at environmental extremes. USARIEM Course, Natick, MA, May 1989.

30. Askew, E.W. Review of USARIEM's evaluation of the nutrition initiatives. Committee on Military Nutrition Research at NAS, 2001 Wisconsin Ave, NW, Washington, DC, December 1989.

31. Askew, E.W. Summary of current USARIEM program activities. Committee on Military Nutrition Research at NAS, 2001 Wisconsin Ave, NW, Washington, DC, May 1989.

32. Baker, C. Military Nutrition Division role in ration testing and development. Framingham State College Experimental Foods Class, Natick RD&E Center, Natick, MA, 25 October 1989.

33. Baker, C. Military Nutrition Division role in ration testing and development. Keene State College Experimental Foods Class, November 1989.

34. Baker, C. Nutrition for work at high altitude. USARIEM Course, Natick, MA, May 1989.

35. Edwards, J.S.A. Results of the 1989 Alaska cold weather MRE supplement packet test. Committee on Military Nutrition Research at NAS, 2001 Wisconsin Ave, NW, Washington, DC, May 1989.

36. Moore, R.J. Nutrition for work in the heat, USARIEM Course, Natick, MA, May 1989.

37. Moore, R.J. Review of sodium content of military rations: are unacclimated soldiers deployed to a hot environment at risk at reduced sodium levels? Research considerations. Committee on Military Nutrition Research at NAS, 2001 Wisconsin Ave, NW, Washington, DC, May 1989.

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38. Morgan T.E. Nutrition for work in the cold. USARIEM Course, Natick, MA, May 1989.

39. Rose, M.S. Dietary assessment of U.S. Army basic trainees. American Dietetic Association Convention, Kansas City, MO, October 1989.

40. Rose, M.S. A comparison of nutrient intakes in garrison dining facilities: Effectiveness and acceptability of nutrient solutions in enhancing fluid intake in the heat. World Wide Nutrition Conference, Fort Lee, VA, March 1989.

41. Rose, M.S. A comparison of soldier nutrient intakes through garrison dining facility studies and dietary assessment of U.S. Army basic trainees. 804th General Hospital Conference for Dietitians, Sheraton Milford Hotel, March 1989.

42. Rose, M.S. Army nutrition in the field and garrison. Army War College, Carlisle Barracks, PA, April 89

43. Rose, M.S. Dietary assessment of basic trainees Ft. Jackson, SC. Armed Forces Product Evaluation Committee Meeting, Natick, MA, May 1989.

44. Rose, M.S. Effectiveness and acceptability of nutrient solutions in enhancing fluid intake in the heat. AMSC Clinical Nutrition Postgraduate Short Course, Washington, DC, April 1989.

45. Rose, R.W. Dietary assessment of U.S. Army basic trainees. World Wide Nutrition Conference, Fort Lee, VA, 9 March 1989.

46. Szeto, E.G. Nutrient intakes in military dining facilities. Massachusetts Dietetic Association, Boston, MA, May 1989.

47. Szeto, E.G. C. Baker, T. Morgan. USARIEM and Natick RD&E Center personnel. Diet and disease reduction. USARIEM Health & Nutrition Fair, March 1989.

MILITARY NUTRITION DIVISION

KEY BRIEFINGS:

48. Eldon W. Askew, LTC, Ph.D. Military Nutrition Division information briefing; Dr. Leroy Jones, Consultant to the Commander, USAMRDC; Natick, MA, 1989.

49. Eldon W. Askew, LTC, Ph.D. Military Nutrition Division research programs; Army Science Review Board, Natick, MA, 1989.

50. Eldon W. Askew, LTC, Ph.D. Military Nutrition research program; COL G.E. McCarty, Deputy Commander, USAMRDC; Natick, MA, 1989.

51. Eldon W. Askew, LTC, Ph.D. Nutrition research at USARIEM; Maj Gen EHA Beckett, Natick, MA, 1989.

52. Eldon W. Askew, LTC, Ph.D. Nutrition research at USARIEM; STAS Panel Review Natick Technology Base Program, Natick, MA, 1989.

53. Eldon W. Askew, LTC, Ph.D. Nutrition research at USARIEM; COL Hamilton-Russell, Assistant Military Attache, British Embassy, Washington, DC; Natick, MA, 1989.

54. Eldon W. Askew, LTC, Ph.D. Performance assessment (USARIEM); STAS Panel Review Natick Technology Base Program, Natick, MA, 1989.

55. Eldon W. Askew, LTC, Ph.D. Ration testing; COL George B. Dibble, Project Officer, Army Field Feeding; Mr. Mario Velez; and Mr. Jimmy Hodges; Natick, MA, 1989.

56. Eldon W. Askew, LTC, Ph.D. USARIEM briefing; COL John Stewart, Chief of Staff, TROSCOM; Natick, MA, 17 January 1989.

57. Eldon W. Askew, LTC, Ph.D. USARIEM nutrition and altitude research; ODA 155 2nd Special Forces Group (AB), Fort Lewis, WA, 1989.

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58. Eldon W. Askew, LTC, Ph.D. USARIEM support to Natick on ration development testing; COL J. W. Kernodle, Commander, U.S. Army Natick RD&E Center; Natick, MA, 1989.

59. J.S.A. Edwards, Lt Col, Ph.D. Alaska cold weather testing; COL George B. Dibble, Project Officer, Army Field Feeding, Mr. Mario Velez, and Mr. Jimmy Hodges; Natick, MA, 1989.

60. J.S.A. Edwards, Lt Col, Ph.D. Military Nutrition Division briefing; WRAIR Fellows; Natick, MA, 1989.

61. J.S.A. Edwards, Lt Col, Ph.D. USARIEM cold weather ration testing; Quarterly Warfighting Review including MG Shaffer, Commander, Alaska National Guard, BG Ebbesen, Assistant Divisional Commander, Maneuver 61D(L), Ft. Richardson, AK, 1989.

62. J.S.A. Edwards, Lt Col, Ph.D., D. Sherman. The conduct of field studies and its future potential for college students; Dr. Huber and students of Simmons College, Boston, MA, 1989.

63. J.S.A Edwards, Maj, Ph.D. MRE supplemental cold weather evaluation; Cold Weather Conference, Directorate of Combat Development, QMS, Fort Lee, VA, 1989.

64. J.S.A Edwards, Maj, Ph.D. MRE supplement cold weather evaluation; 28th meeting DOD Food and Nutrition Research and Engineering Board, DOD Food and Nutrition RDTE&E Program, Natick, MA, 1989.

65. J.S.A Edwards, Maj, Ph.D. Nutrition research at USARIEM; Maj Gen EHA Beckett; Natick, MA, 1989.

66. J.S.A. Edwards, Maj, Ph.D., LTC Askew, Ph.D., LTC Rose, Ph.D., CPT Moore, Ph.D. Nutrition research at USARIEM/USANRDEC, Cold weather MRE/Supplemental Pack Test; Visit of Col Hamilton-Russell, Assistant Military Attache, British Embassy; Natick, MA, 1989.

67. Robert Moore, CPT, Ph.D. Future nutrition research; COL Hamilton-Russell, Assistant Military Attache, British Embassy, Washington, DC; Natick, MA, 1989.

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68. Robert Moore, CPT, Ph.D. Operational ration testing in environmental extremes; Dr. Sang Kyu Lee, the Korean Associate Technical Project Officer, Agency for Defense Development, Republic of Korea; Natick, MA, 1989.

69. Madeleine S. Rose, LTC, Ph.D. Fort Jackson nutrition assessment results; Armed Forces Product Evaluation Committee; Natick, MA, 1989.

70. Madeleine S. Rose, LTC, Ph.D. Military Nutrition Division information briefing; MAJ W.M. Low and CPT S. Kuman, Singapore Armed Forces, Republic of Singapore; Natick, MA, 1989.

71. Madeleine S. Rose, LTC, Ph.D. MRE supplemental packet cold weather evaluation; Army Nutrition Planning Committee, Washington, DC, 1989.

72. Madeleine S. Rose, LTC, Ph.D. NBC solutions; COL Hamilton-Russell, Assistant Military Attache, British Embassy, Washington, DC; Natick, MA, 1989.

SIGNIFICANT TDY:

CPT R.J. Moore, Ph.D. Joint Working Group, Feeding the Soldier Meeting, Fort Lee, VA, 24-25 January 1989.

CPT E. Szeto. Attendance at Combined Armed Services and Staff School Fort Leavenworth, KS, February-June 1989.

LTC E.W. Askew, Ph.D., LTC M.S. Rose, Ph.D., CPT R. Moore Ph.D. Committee on Military Nutrition Workshop on The Use of Carbohydrate Electrolyte Replacement Beverages by Soldiers in the Field, National Academy of Sciences, Washington, DC, 16-17 February 1989.

Maj J.S.A. Edwards, Ph.D. et al. MRE supplemental cold weather evaluation research study, Fort Greely/Fort Richardson, AK, 22 February-5 March 1989.

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LTC E.W. Askew, Ph.D. Site visit for LSU Grant, Fort Polk, LA, 27, 28 February 1989.

LTC M.S. Rose, Ph.D., and R.W. Rose. Army Nutrition Planning Committee Meeting, Fort Lee, VA, 10 March 1989.

Ms. C. Baker and Ms. T. Morgan. Preliminary evaluation of ration, lightweight with carbohydrate beverage supplement at altitude, Fort Lewis, WA, 16-19 & 24-25 March 1989.

LTC M.S. Rose, Ph.D. Instructor for Advanced Nutrition Course, Army War College, Carlisle Barracks, PA, 10 April 1989.

LTC M.S. Rose, Ph.D. AMSC Clinical Nutrition Postgraduate Short Course, Washington, DC, 12 April 1989.

LTC E.W. Askew, Ph.D., Lt Col J.S.A. Edwards, Ph.D., CPT R.J. Moore, Ph.D. Committee on Military Nutrition Review of Cold Weather Feeding and Sodium Requirement Studies, Washington, DC, 22 May 1989.

Ms. D.E. Sherman. Fourteenth National Nutrient Databank Conference, Iowa City, Iowa, 19-21 June 1989.

LTC E.W. Askew, Ph.D., and Maj J.S.A. Edwards, Ph.D. Joint Working Group on cold weather field feeding, Fort Lee, VA, 26-28 June 1989.

LTC M.S. Rose, Ph.D. MRE supplemental cold weather evaluation to Army Nutrition Planning Committee, Washington, DC, 27 June 1989.

Ms. C. Baker and Ms. T. Morgan. High altitude study to evaluate RLW at altitude and benefit of carbohydrate supplementation, Pike's Peak, Colorado, 16-30 July 1989.

LTC M.S. Rose, Ph.D. M.L. Hamrick Research Course, Leesburg, VA, 31 July-4 August 1989.

LTC E.W. Askew, Ph.D. Basic and clinical aspects of regional fat distribution, National Institutes of Health, Bethesda, MD, 11, 12 September 1989.

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Lt Col J.S.A. Edwards, Ph.D. Participated in 6th ID Quarterly winter Warfighting Review and site visit, Ft. Richardson and Ft. Wainwright, AK, 29 October-2 November 1989.

SIGNIFICANT VISITORS:

Dr. Henry Lukaski, USDA Human Nutrition Research Center, Grand Forks, ND, 9 January 1989.

Dr. David Coursin, affiliated with Georgetown University, Washington, DC, 2 February 1989.

Dr. Molly Kretsch, USDA Western Human Nutrition Research Center, Presidio of San Francisco, CA, 5 April 1989.

Dr. J.P. Hannon, Science Director, Letterman Army Institute of Research, Presidio of San Francisco, CA, 18 April 1989.

COL David D. Dee, Director, Food Services, U.S. Army Troop Support Agency, Fort Lee, VA, 3 May 1889.

Dr. Joel Grinker, Human Nutrition Research Center on Aging, Tufts University, Boston, MA, 17 May 1989.

Col M. Daly, British Medical Liaison Officer, British Embassy, Washington, DC, 25 May 1989.

Maj Gen E.H.A. Beckett, Defence Attache, British Embassy, Washington, DC, 30 May 1989.

Col Hamilton-Russell, Assistant Military Attache, British Embassy, Washington, DC, 21 June 1989.

Lt Gen Sir Edward Jones, Quartermaster General; Brigadier Robin D. Grist, OBE, Military Attache and Commander British Army Staff, 13 September 1989.

Rear Admiral David Allen, Royal Navy Chief of Naval Supply Secretariat Office, 21 September 1989.

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Dr. J. E. Canham, COL (retired), formerly commander of Nutrition Laboratory at Fitzsimmons and U.S. Army Letterman Institute, currently Director, Medical Affairs, Kabbi, Inc., Clayton, NC, presented a seminar on Military Nutrition History in the U. S. Army, 5 October 1989.

COL G.B. Biddle, Project Officer, Army Field Feeding, 5 October 1989.

Dr. James DeLaney, LSU Stable Isotopes Laboratory, visited and conferred with Military Nutrition Division investigators on stable isotope and analytical support for USARIEM (LSU Grant), 7 December 1989.

PROFESSIONAL APPOINTMENTS/ACTIVITIES:

LTC J.S.A. Edwards, Ph.D. Member and United Kingdom Representative, NATO Panel 8, R.S.G. 8. Nutritional Aspects of Military Feeding.

LTC Eldon W. Askew, Ph.D. Invited reviewer for Natural Sciences and Engineering Research Council of Canada (NSERC) Research Grants.

LTC Eldon W. Askew, Ph.D. Invited reviewer for J. Nutrition and J. Appl. Physiol.

LTC Eldon W. Askew, Ph.D. Panel member, U.S. Olympic Ad Hoc Committee on Sports Nutrition.

LTC Madeleine S. Rose, Ph.D. Assistant Professor, Department of Nutrition and Food Science, South Dakota State University.

APPENDIX

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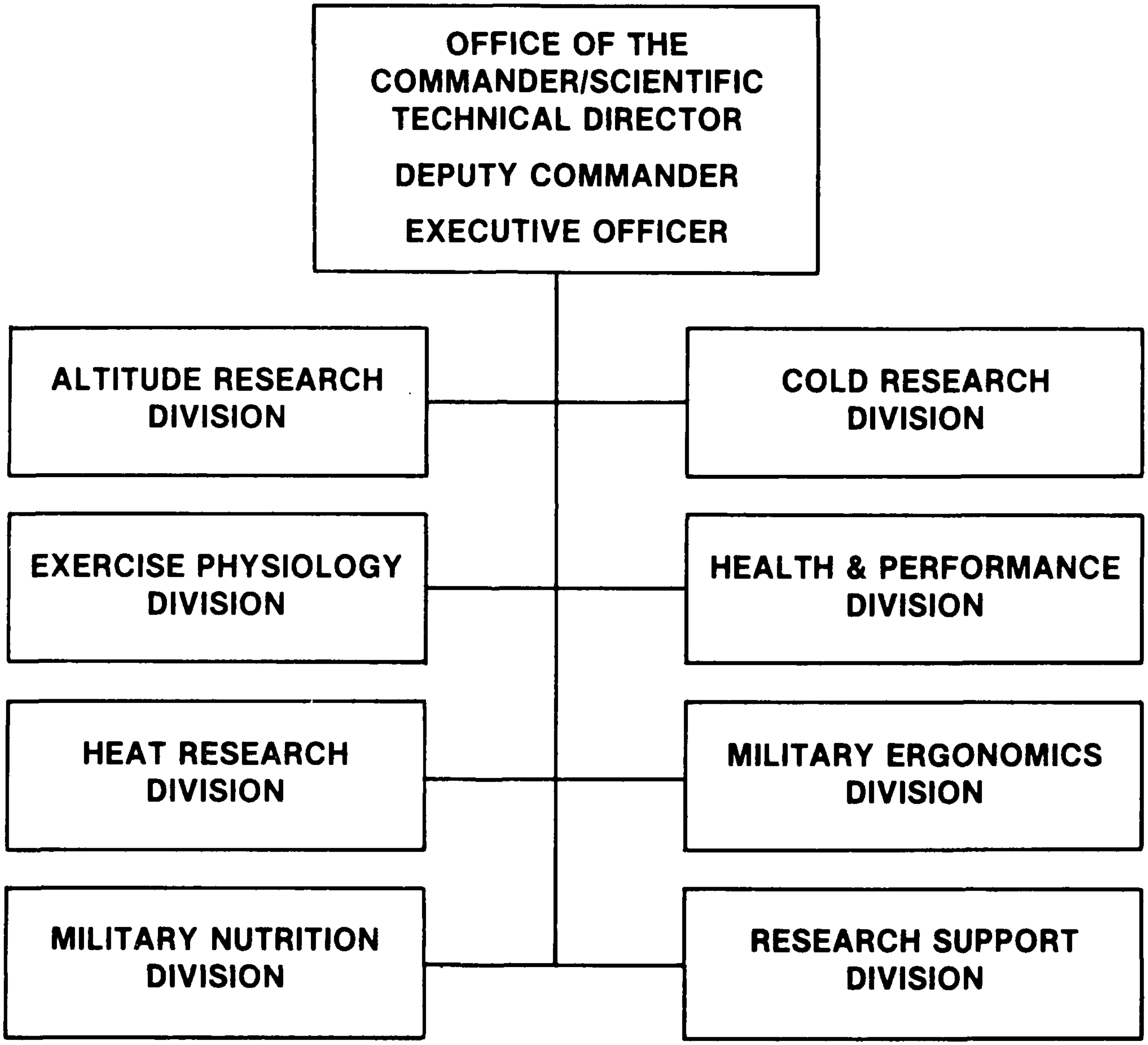

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